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UTILIZING SUN RAYS

By Dr. C. G. ABBOT

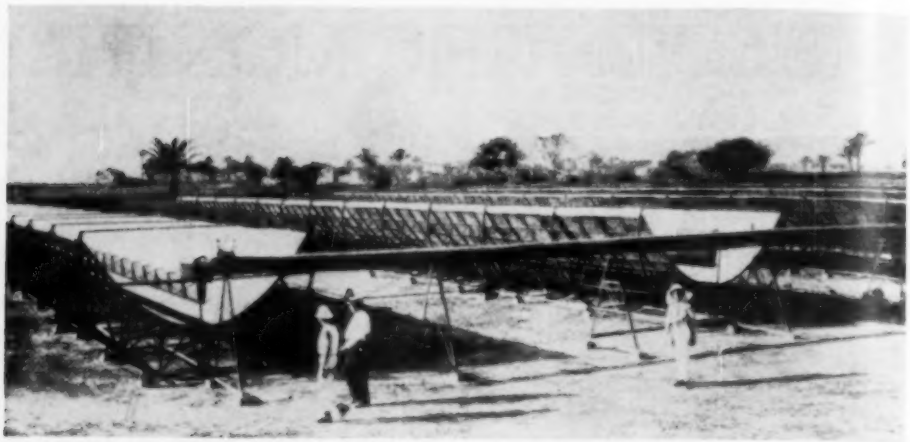
SECRETARY OF THE SMITHSONIAN INSTITUTION

ACCORDING to the clearness of the day the sun's beam contains energy at the rate of from 1.0 to 1.5 calories per square centimeter per minute at the earth's surface. On a square meter of surface at right angles to the beam, this corresponds to from 1.02 to 1.52 horsepower per square meter, or to the raising of 0.16 to 0.24 kilograms of water at 20° to steam at 100° C. Thus the counties of Grant, Sierra, Hidalgo and Luna in New Mexico, or the southern part of Florida from a line connecting Sarasota with Fort Pierce, receive as much energy from the sun per year as is used annually for all purposes—power, heat and light—in the United States.

Several drawbacks have hitherto prevented extensive use of solar energy for power and other purposes. They are: First, the considerable area required to collect large quantities of power as compared to other prime moving sources. Second, the wandering of the sun in the sky by day and by season. Third, the intermittence of solar radiation caused by clouds and night. It is true that for some limited purposes, including the evaporation of water and the heating of water for domestic uses, these objections are not very serious. But for the main object, solar power, they are all of consequence. Two devices have indeed been used with some success to avoid following the wanderings of the sun in the sky. Willsie and Boyle, about thirty-five years ago, developed the use of a shallow black-bottomed pond of water to absorb heat sufficient to operate a sulfur dioxide engine at a low temperature. Their plant at Needles, Arizona, is described in *Engineering News*, May 13, 1909. On account of the considerable inclination of solar rays, the reflection from the surface of the pond and its glass cover and the low thermodynamic factor associated with the low temperature, their efficiency factor was, of course, very low, so that the area required per horsepower was fully a hundred times that given above. On the other hand, the heat collector was relatively inexpensive.

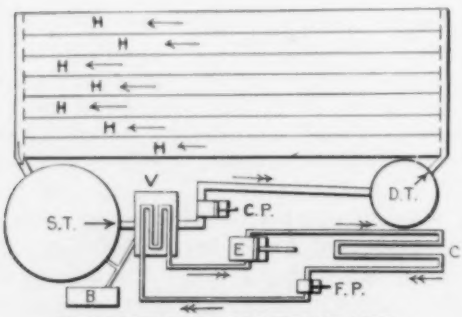
Giovanni Andri, of Milan, has installed a number of solar power plants in Italy and Africa in which the heater is a blackened flat metal box, having a limited adjustment about a horizontal axis, and also operating a low-temperature engine. Except for reflection, the considerations just mentioned for the black-bottomed pond will probably apply to his device, although I have no exact information as to its performance.

Of devices intended to follow the sun, the two most noted of recent times are that of A. G. Eneas, employed about thirty-five years ago to pump water at South Pasadena, and that of the Eastern Sun Power Limited, near Cairo, Egypt, used for irrigation in 1913 (see Smith-



GENERAL VIEW FROM SOUTH OF SHUMAN–BOYS ABSORBER, MEADI, 1913

THIS DEVICE WAS ERECTED BY THE EASTERN SUN POWER LIMITED NEAR CAIRO, EGYPT, AND OPERATED IN 1913 IN CONNECTION WITH A STEAM ENGINE FOR PUMPING WATER FROM THE NILE FOR IRRIGATION PURPOSES. THE SUN'S RAYS SHINING UPON THE LONG TROUGH-LIKE MIRRORS WERE REFLECTED TO FOCUS UPON A METAL STEAM BOILER TUBE WITH A WEDGE-SHAPED CROSS SECTION, AND THE STEAM FROM A SYSTEM OF MIRRORS WAS COLLECTED IN THE STEAM PIPE LEADING TO THE ENGINE. THE ENGINEERS CLAIMED AN EFFICIENCY GREAT ENOUGH SO THAT THE DEVICE COULD PRACTICALLY COMPETE WITH COAL IN THAT COUNTRY FAR FROM MINES.



WILLSIE SUN POWER PLANT

WATER FROM THE DISTRIBUTING TANK D. T. AFTER FLOWING THROUGH THE GLASS-COVERED TROUGHS H. H. H. ABSORBING SOLAR HEAT IS STORED IN THE STORAGE TANK S. T. THIS HOT WATER GIVES UP ITS HEAT IN THE VAPORIZER V AND IS SENT BACK BY THE CIRCULATING PUMP C. P. TO THE DISTRIBUTING TANK. SINGLE-HEADED ARROWS INDICATE THE FLOW OF THE WATER. EMERGENCY STEAM BOILER, B, FOR CLOUDY PERIODS. SULFUR DIOXIDE FLOWS IN THE DIRECTION OF THE DOUBLE-HEADED ARROWS FROM THE VAPORIZER COILS TO THE ENGINE E. THE EXHAUST VAPOR GOES TO THE CONDENSER C. THE LIQUID SULFUR DIOXIDE IS RETURNED BY THE FEED PUMP F. P. TO THE VAPORIZER. THE DISTRIBUTING TANK IS SMALL.

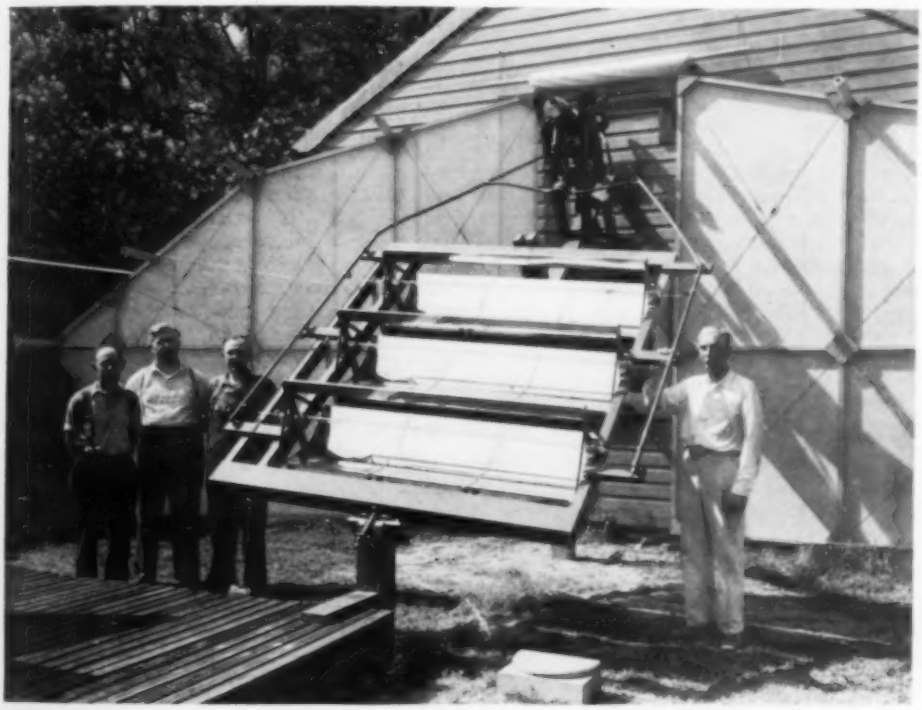
sonian Report, 1915). Mr. Eneas had a conical frame of steel, some 30 feet in diameter, lined with glass mirrors, and mounted to follow the sun both from east to west daily, and from north to south seasonally. A boiler in the focus raised steam for power. However, the machine was too complex and costly for commercial success. The English development near Cairo came nearest to commercial success of any, unless possibly the blackened pond of Willsie and Boyle. It employed cylindrical metal mirrors to raise steam in long tubular boilers at their foci, and rotated the mirrors about horizontal axes to approximately follow the sun from east to west daily.

In recent times the advances in development of aluminum alloys, and in vacuum technique, have greatly simplified the design of efficient solar power devices. With these industrial advances is to be combined an application of long-established astronomical practice to pro-

duce a cheap and effective solution of the solar power problem.

It is familiar to astronomers, though, as patent records show, not so much so to engineers, that the simplest way to follow the sun in its daily course is to mount the device to rotate 15° per hour about an axis parallel to the axis of the earth. For large installations, covering square yards rather than square inches, mirrors are far cheaper than lenses. As for also following the sun from north to south from June to December, this involves, at simplest, motions about two axes, and requires means of transferring heat from a moving boiler to a stationary engine. Hence, it is best to make no provision for the motion north to south, and to use an elongated cylindrical mirror of parabolic section reflecting the sun rays upon a heater tube parallel to the axis of the earth. Part of the mirror is lost except on March 21 and September 21, but this loss is not serious.

The mirror is to be rotated about the center of the heater-tube itself as an axis. In the solar cooker on Mount Wilson, Calif., I used a weight to rotate a mirror of about 100 square feet capacity, regulating its motion by means of an ordinary alarm clock. But where 60-cycle electric current is available it is neater to use a



HALF HORSEPOWER SOLAR ENGINE

AS EXHIBITED TO THE INTERNATIONAL POWER CONGRESS. IN THIS DEVICE THE MIRRORS OF ALCOA SHEET WERE MOUNTED EAST AND WEST IN A FRAME WHICH TURNED ON AN AXIS PARALLEL TO THAT ON THE EARTH. THE SOLAR RAYS STRIKING THE MIRRORS WERE BROUGHT TO A FOCUS ON ELONGATED THERMOS BOTTLES CONTAINING THE HIGH BOILING POINT LIQUID "AROCLOR." THE HEATED LIQUID PASSED BY GRAVITY CIRCULATION TO A BOILER AT THE REAR FROM WHICH THE STEAM PASSED THROUGH A SMALL OPENING. A FEW DAYS LATER THE NATIONAL BROADCASTING COMPANY MADE A COUNTRY-WIDE BROADCAST FROM THIS DEVICE.

FLASH BOILER AND TOY SOLAR COOKER

THE PRESENCE OF ROLLING CLOUDS IN THE SKY FREQUENTLY SPOILS AN OTHERWISE EXCELLENTLY CLEAR DAY FOR THE LARGE APPARATUS, FOR THE LARGE CAPACITY OF HEAT OF THE BOILER REQUIRES A LONG TIME TO RAISE STEAM TO THE PROPER PRESSURE. A FLASH BOILER HAS THEREFORE BEEN DEVELOPED IN WHICH THE BOILER TUBE HAS A VERY SMALL CAPACITY FOR HEAT, AND WATER IS INTRODUCED ONLY AS FAST AS THE STEAM IS MADE. IN THIS APPARATUS THE MIRROR IS MOUNTED ON AN AXIS PARALLEL TO THE AXIS OF THE EARTH AND IS ROTATED BY A WHEEL MECHANISM DRIVEN BY A 60-CYCLE SYNCHRONOUS MOTOR. FULL PRESSURE OF STEAM IS RAISED WITHIN FIVE MINUTES OF THE TIME THE SUN BURSTS OUT OF THE CLOUDS. IN FRONT OF THE FLASH BOILER IS SHOWN THE TOY COOKING APPARATUS IN WHICH LITTLE GIRLS BAKE DOLLS' CAKES AND LITTLE BOYS SEE SMALL SOLAR ENGINES IN OPERATION.

worm-and-wheel drive, operated by a synchronous motor. A large, well-balanced mirror, supported on rollers, can be moved thus with the expenditure of less than 1/1000 horsepower in electricity.

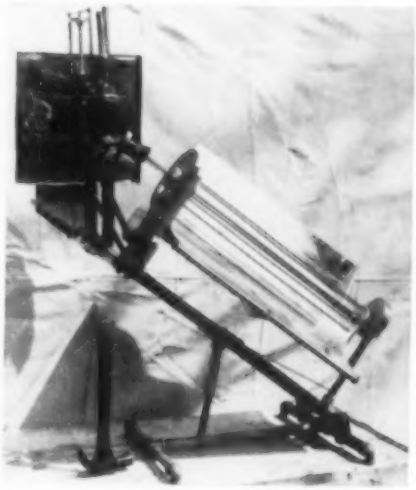
For the construction of the mirror, a cradle of duralumin, having a parabolic cross section, is made. To this is clamped down by metal straps thin sheets of "Alcoa," of highly reflecting and permanent surface, which is now a commercial article by the Aluminum Company of America. Such a mirror reflects about 80 per cent. of solar radiation. I have several such mirrors, now five years old, which, despite dust and an occasional wetting, now polish off with absorbent cotton apparently as brightly reflecting as ever.

The stationary heater-tube of blackened metal, about which the mirror rotates, passes through hollow trunnions. It is closely surrounded by a vacuum jacket of pyrex glass, in the form of an elongated thermos bottle. In the "flash" solar-boiler device, the thermos bottle is closed at the bottom, and water is led into the boiler in a small metal tube which discharges within the lower end. The water flashes into steam, which exists above the top of the mirror towards the engine.

In the solar distilling device, there is a

reservoir for the water to be distilled at the level of the upper part of the mirror. A snout-tube passes downwards parallel to and under the mirror, turns upwards at right angles and again bends at right angles as a gigantic U to form the blackened heater-tube. Inside of the heater-tube there returns through the U, and quite through the water of the reservoir, a steam tube. There is an opening at the lowest point from the steam tube through the snout where condensed water drips into a receptacle. It will be seen that the water to be distilled is preheated in cooling the steam, so that only the latent heat of evaporation needs to be supplied.

With one solar distillation, I have made, from Atlantic Ocean stock, water so pure that it gives no cloud with silver nitrate. The yield from a mirror of about 11 square feet is about 2 gallons per day, in fine weather. The distiller is automatic, and works whenever the sun shines unclouded.



TOY SOLAR COOKER

SHOWING THE OVEN AND THE ENGINE, AND BELOW THE SMALL MIRROR OF ALCOA SHEET WITH ITS ELONGATED THERMOS BOTTLE THROUGH WHICH THE BLACK HIGH BOILING POINT LIQUID CIRCULATES, AND THE ALARM CLOCK MECHANISM UNDERNEATH WHICH GEARS WITH THE MIRROR.

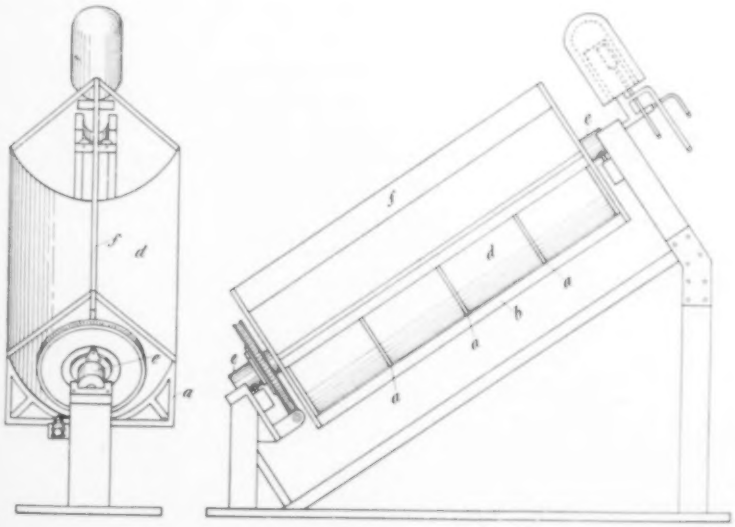


DIAGRAM OF SOLAR FLASH BOILER

THE MIRROR, AAA, IS MOUNTED TO ROTATE ON BEARINGS, E, PARALLEL TO THE AXIS OF THE EARTH. THE SOLAR RAYS COME TO FOCUS ON THE BOILER TUBE, WHICH IS CONCENTRIC WITH THE BEARINGS. THE BOILER TUBE IS OF BLACKENED METAL SURROUNDED BY AN ELONGATED THERMOS BOTTLE LEADING TO THE BOILER. A SMALL STEAM CHEST IS SHOWN AT THE TOP FROM WHICH PIPES GO TO THE ENGINE.

The flash boiler for power purposes is also automatic. The supply of water is governed by the temperature of the boiler tube. Thus as soon as the sun comes out of a cloud, water begins to flow. The stroke of the pump is governed by boiler temperature, and increases as the sun rays grow stronger, until the flow of the water is so rapid that no increase of temperature occurs. I have been accustomed to use steam pressures up to 150 pounds per square inch. Pressure comes to maximum in about 5 minutes, so that days when clear unclouded sky is occasionally beset by cumulus clouds covering the sun are still useful for power.

As a boiler, the efficiency is about 64 per cent. With a thermodynamic factor of 34 per cent. and a turbine efficiency of 75 per cent. the efficiency of converting solar radiation to actual power comes out about 15 per cent. Thus with 4 to 7 square meters of mirror surface, according to the clearness of the atmosphere, there should be yielded 1 horsepower in mechanical work.

When one considers the storage of power to cover times of cloudiness and night, it is obvious that the more cloudy parts of the world will not be used profitably for solar exploitation. But in desert conditions it seems probable that if a flash boiler were connected to a grid of heater pipe within a strong cylinder, superheated water might be accumulated, from which steam could be drawn when direct solar heating is unavailable.

Cooking by solar radiation is readily done. In devices for this purpose I surround the oven with a space filled by a black liquid of high boiling point, and I arrange a gravity circulation between this liquid sheath and a thermos tube, filled with the same liquid, and fixed in the focus of a mirror. The oven is preferably protected from loss of heat by a thick layer of insulation, such as glass wool.

There is great public interest in solar utilization. Letters come almost daily from parties interested in one or more of the uses I have described. But though well-acting models exist of the flash boiler, the solar distilling device and the solar cooker, it has not as yet been possible to undertake production in quantity. Until this is done, it would be hopelessly costly to make these solar devices one at a time. But when wholesale production is accomplished, I believe that solar power can be produced, with fair return on the investment, at not above 0.5 cents per horsepower hour.

CONSERVATION IN PUEBLO AGRICULTURE

I. PRIMITIVE PRACTICES

By Dr. GUY R. STEWART

SENIOR SOIL CONSERVATIONIST, SOIL CONSERVATION SERVICE, U. S. DEPARTMENT OF AGRICULTURE

In the arid Southwest we find some of the oldest settled agricultural communities in the United States among the twenty-six Pueblo villages. The sketch map, Fig. 1, shows the general extent of the Pueblo country which embraces the southern portions of Utah and Colorado, with the states of Arizona and New Mexico, together with adjacent areas of northern Chihuahua. It is a land with a wide diversity of topography and great variations in local conditions, but the environment presented certain similarities in the problems the early agriculturist had to solve in order to obtain a living. Throughout much of the region high summer temperatures may prevail, although on the upland plateaus, as at Mesa Verde and the Taos Valley, the elevation reduces extreme heat. Over the entire region, however, rainfall has frequently been deficient and at all times is highly variable, so that moisture has been the greatest limiting factor in crop growth. All the settled tribes that have lived in this land of desert and mesa have had a unifying interest; they have been sedentary farmers using a specialized maize agriculture as their principal support, in a country where average conditions are more rigorous than those found in the Dust Bowl.

—*Stewart*

FAR VIEW HOUSE AT MESA VERDE

THE LARGEST CENTRAL PART OF THE GROUP OF VILLAGES, NEAR THE HEAD OF THE FLOOD WATER DITCH ON CHAPIN MESA.

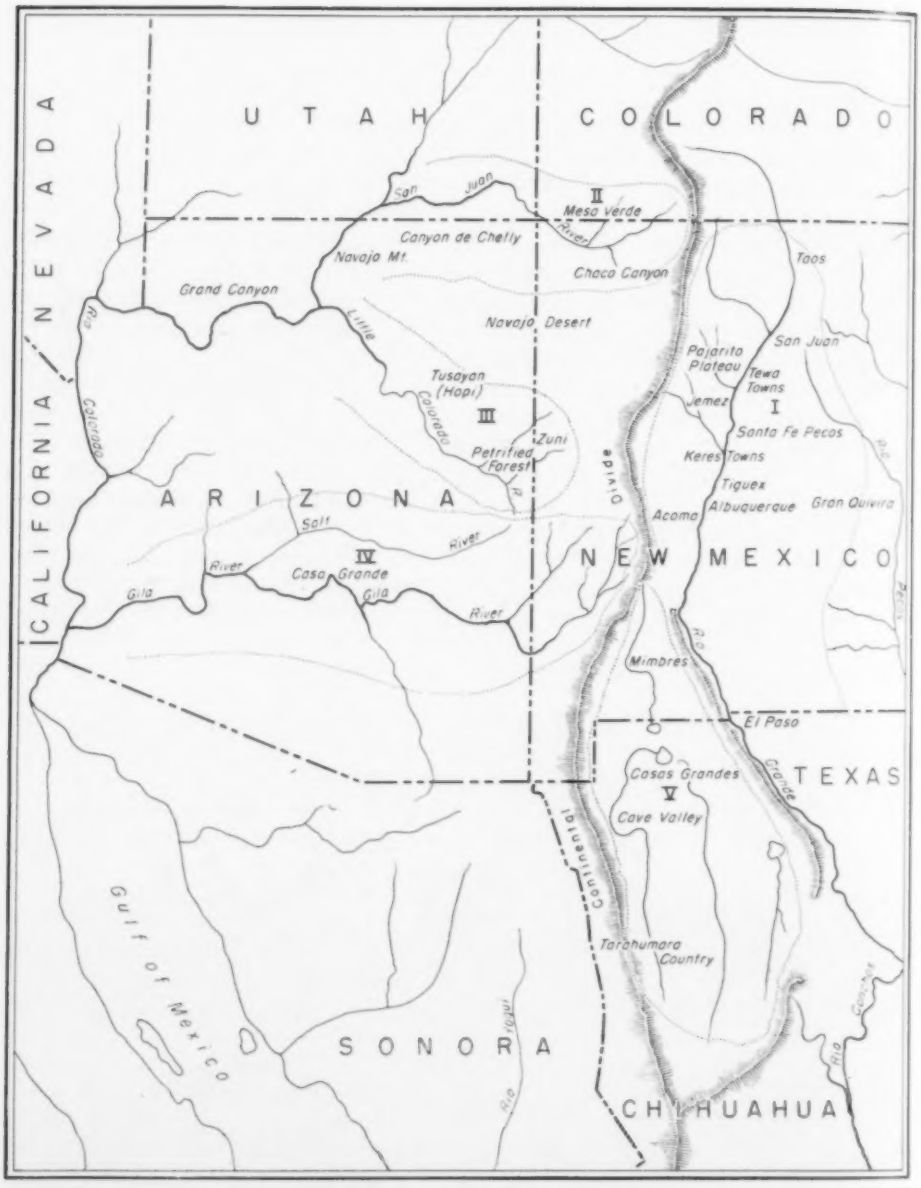


FIG. 1. MAP OF THE PUEBLO PLATEAU

PUEBLO CULTURE AREAS: I—RIO GRANDE; II—SAN JUAN; III—LITTLE COLORADO; IV—GILA; V—MIMBRES CHIHUAHUA. AFTER MAP BY SCHOOL OF AMERICAN RESEARCH.

—Stewart

ONE OF THE STRIKING REMNANTS OF THE EARLY MESA TOP
FOUND NOT FAR FROM THE NORTH ENTRANCE TO MESA VERDE NATIONAL PARK.

When Coronado reached Hawikuh, the most southerly of the famed "Seven Cities of Cibola," constituting part of the Zuni group of villages, he was disappointed with the lack of the reputed stores of gold, silver and precious stones. As he explored the Pueblo country he found, however, a group of some eighty agricultural communities with a well-organized system of agriculture. These villages, in fact, had sufficient surplus corn so that Coronado and his three hundred and twenty men, with their native helpers from Northern Mexico, were able to obtain supplies of maize during the two years they remained in the Pueblo land.

The writer has been interested for several years to find what could be learned of the agricultural practices of the early Pueblo tribes, particularly of the use which they made of conservation measures that would conserve water and soil and enable the primitive cultivator to live in this western land with its strong sunshine throughout the year, together with the dry variable winds of the spring and the fall.

Two sources of information have been available; the first of these is the evidence still obtainable around the early sites showing agricultural usage, such as flood water diversion, water retention dams or irrigation ditches, together with records of such usage in the writings of the large group of ethnologists and archeologists who have worked in the Southwest. The second is from the study of the agricultural methods of the present-day Hopi and Zuni tribes who have been the least affected of the Pueblo peoples by Spanish and American influence. Here one can still see the entire life of the people centered around the ritual observances which they feel are essential to bring rain to the thirsty land

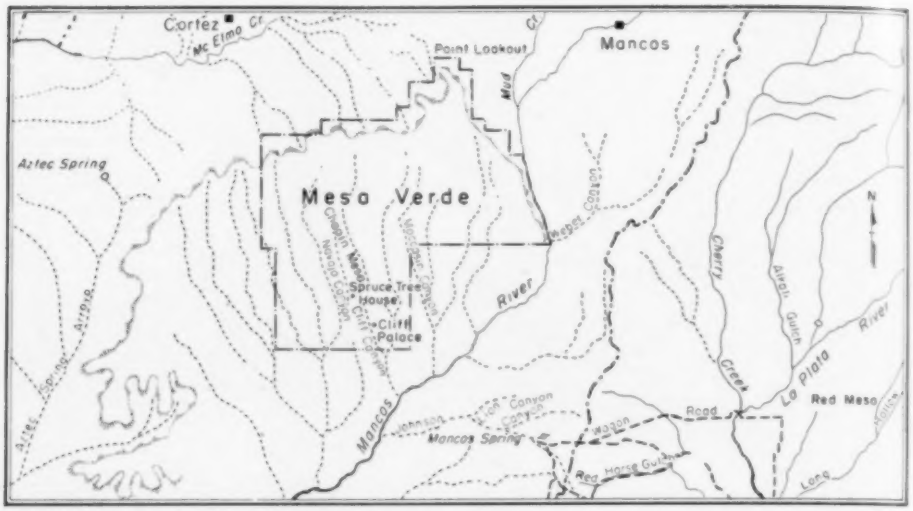


FIG. 2. SKETCH MAP OF MESA VERDE PLATEAU, SOUTHWEST COLORADO

—*Holzman*

FAR VIEW RUIN NEAR UPPER PART OF FLOOD WATER DITCH

—*Holzman*

CHECK DAMS ON WEST BRANCH OF SODA CANYON, MESA VERDE
PROBABLY USED FOR VILLAGE GARDENS.

and which mark as well each stage in the development of their greatest crop, the corn plant.

In the preliminary work so far carried out the writer has been aided by information from friends and associates in the Soil Conservation Service, by scientists and officials of the National Park Service, as well as by members of the staffs of the several Southwestern museums and interested specialists of the faculties of the Universities of Arizona and New Mexico.

When Spanish exploration of the Pueblo country started in 1540, the most important native settlements in the region were confined to the Rio Grande country, together with the Hopi and Zuni villages. Even there abandonment and resettlement of early sites had taken place on a large scale. One of the most important groups of Pueblo villages, that of the Mesa Verde Plateau, had been given up so long before the appearance of the Spaniards that no reference to it occurs in any of the Spanish narratives of exploration. Hence, one is certain that evidence of agriculture found there is quite unaffected by old world influence.

Flood Water Agriculture at Mesa Verde

A sketch map of the Mesa Verde Plateau, in southwestern Colorado, is shown in Fig. 2, together with the portion of the area included in the Mesa Verde National Park. The present-day visitor to the park approaches from the northerly side of the fan-shaped tableland, over the excellently laid out modern highway, instead of coming in over the trails from the Mancos River, as Richard Wetherill and Charley Mason did when hunting for cattle in December, 1888. As they searched for lost stock

—*Stewart*

PRESENT STATE OF MUMMY LAKE

PRIMITIVE INDIAN FLOOD WATER RESERVOIR ON CHAPIN MESA, MESA VERDE.

—*Holzman*

CROSS SECTION OF UPPER PART OF INDIAN FLOOD WATER DITCH

NEAR FAR VIEW GROUP, MESA VERDE. JAMES A. LANCASTER IS IN THE FOREGROUND.

along Chapin Mesa they had the notable experience of finding the splendid ruined villages of Cliff Palace and Spruce Tree House in the same day. Their surprise could hardly have been greater had they found these two sites occupied by the early inhabitants. The impression made on almost every visitor who looks on these extensive towns for the first time is that of viewing something unreal. Even before the two sites were restored, both villages appeared to be astonishingly complete and ready to spring again into life and activity.

The modern road climbs up to the higher rim of the plateau, past striking remnants of the mesa top, segregated and left standing apart in early geologic time. On reaching the top of the divide it brings one near Park Point, where a sweeping view is obtained, showing the extent of the fan-shaped tableland, reaching some 15 miles east and west and 12 miles north and south. As the visitor comes down the highway along Chapin Mesa he reaches the Far View group of ruins which is near the upper end of an unusually complete unit of early flood water irrigation. The extent of this system on Chapin Mesa is indicated in Fig. 3, which shows a primitive flood water ditch that apparently supplied corn fields and check dam garden areas along the mesa top. The mapping was carried out by the Soil Conservation Area office, Farmington, New Mexico, during the past year.

The definite beginning of this flood water system is a little above Far View House and consists of a circular reservoir commonly known as Mummy Lake. This ancient reservoir has been mentioned ever since the first explorations on the mesa, but its possible connection with flood water irrigation was not recognized until James A. Lancaster of the park staff made a careful study of the area. Some indication was noted during the writer's field work, suggesting that feeding ditches possibly continued up the mesa above Mummy Lake. There is no present sign, however, of a more continuous source of supply than surface run-off from the upper portions of Chapin Mesa, where precipitation appears to be heavier with the increase in elevation.

FIG. 3. FLOODWATER IRRIGATION DITCH AND CHECK-DAM AREAS, CHAPIN MESA

It is known that Mummy Lake was used by cattlemen for water storage for a few years following the discovery of the principal ruins. Examinations of the profile of the deposits in the bottom of Mummy Lake by R. J. Finley, conservation surveyor, and the writer,

FIG. 4. CHECK-DAM AREAS ON TWO BRANCHES OF SODA CANYON

showed a deposition of stratified silt and sandy clay loam reaching to a depth of approximately 10 feet. This appears to be a far greater deposit than would ordinarily have developed from the run-off water on the mesa unless Mummy Lake had been used for water storage over a long period of years.

Along the ditch evidence was found at several points indicating where water might have been turned out on the corn fields. In a few places it is possible that additional flood water was also picked up. In some spots the bed of the ditch was stabilized with rock cross checks and the bank on the lower side was sometimes reinforced with stones. A typical cross section of the upper part of the ditch is shown in an accompanying view. The entire length of the flood water supply ditch from Mummy Lake to the lower check dam areas measures approximately four miles.

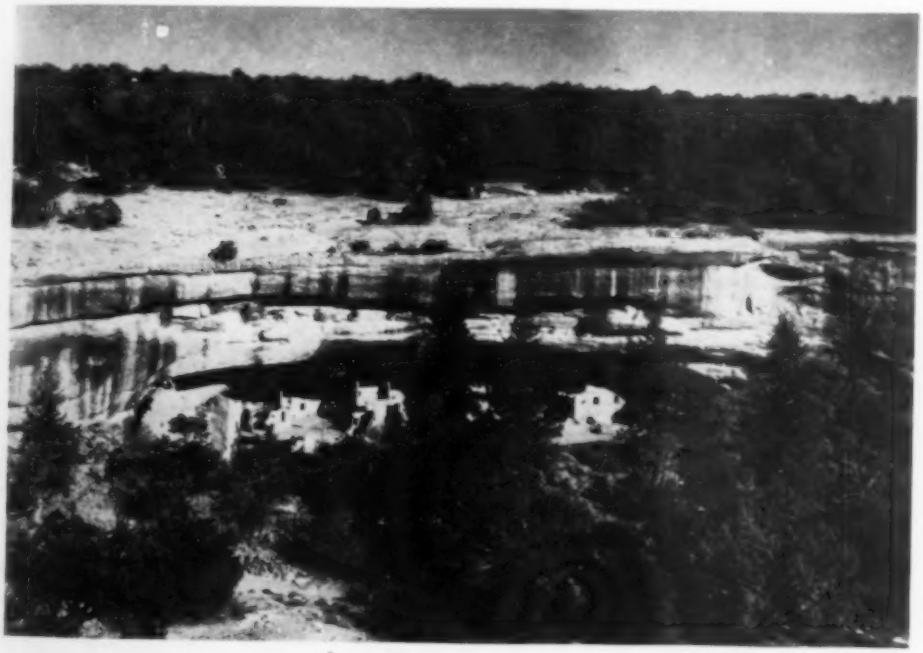
It is worthy of note that the cross section of the ditch is relatively broad and flat and is almost identical with the type of ditch outline developed by the Soil Conservation Service for terrace outlets and other vegetated waterways. Finley and the writer made a series of measurements of the cross section at somewhat over a dozen points along the ditch. These showed that the width of the ditch varied from a minimum of about 23 feet to a maximum of over 43 feet, with an average of 30 feet 6 inches. The depth varied from 6 inches to 18 inches, with an average of about 11 inches. Relatively little erosion had occurred in this type of flood water channel. This was probably due largely to the broad, shallow cross section which has tended to prevent concentration of flood water, with consequent cutting of a central channel.

At the present time, the land occupied by the ditch and that adjacent to it supports an open stand of piñon pine (*Pinus edulis* Engelm.), mixed with juniper (*Juniperis Utahensis*). Increment borings made in the larger piñon trees showed an age usually of from 140 to 155 years, with a maximum of 175 years. Since the piñon pine, according to Sudworth, has an age of only 100 to 225 years and no appreciable number of old stumps are visible, it is probable that the trees have gradually seeded in from land carrying trees adjacent to the flood water irrigated areas.

In the lower part of Fig. 3, it will be seen that the profile or grade of the ditch is remarkably uniform through its entire course, even though the ditch follows a

somewhat irregular line down the mesa. This would point to some definite plan or method of engineering to obtain this result over a distance of 4 miles and indicates skill of an exceptional type among these primitive cultivators. Had the ditch been run with only a slight fall, as was often the case with early Indian ditches examined by the writer in the Salt River Valley, it would have been easy to construct an excavation by having standing water follow the excavators. Where a steeper gradient was used, however, a more advanced technique was evidently required.

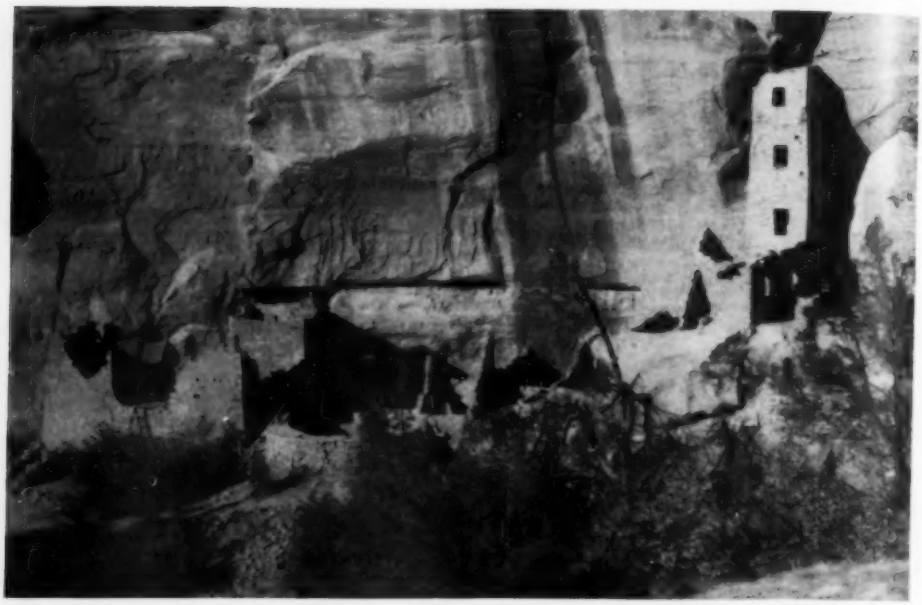
Two areas of garden check dams were located adjacent to the flood water ditch on separate branches of Soda Canyon. The general location of each group is shown in Fig. 3, and a larger scale mapping is presented in Fig. 4. The check dam type of village garden is a characteristic feature of the agriculture at Mesa Verde, and groups of these small garden plots are found close to many of the ruins upon the plateau, as on Wetherill Mesa near Kodak House, Long House and Jug House. Similar groups of check dams were examined on the mesa at the head of Moccasin Canyon. The probable use of these plots for village gardens has been recognized for many years by the Park Service staff at Mesa Verde. The individual check dam gardens vary widely in size. Some may be as small as 6 feet by 9 feet, while others are as wide as 35 to 45 feet, with a probable cultivable breadth of 10 to 15 feet to the base of the next check dam. The checks all have a definite type of construction, with the corner of the dam well toed in to the bank in order to stabilize the structure. They were, in most cases, built on rock ledges and originally contained about 3



—*Holzman*

SPRUCE TREE HOUSE AT MESA VERDE

NEAR LOWER END OF INDIAN FLOOD WATER DITCH, WITH A PROBABLE POPULATION OF 350 PEOPLE.



—*Stewart*

SQUARE TOWER HOUSE, MESA VERDE

DISTINGUISHED FOR ITS HANDSOME TOWER AND WELL-PRESERVED CEREMONIAL KIVAS.

to 4 feet of soil which would have been adequate to mature shallow-rooted crops such as beans, early corn, squash and pumpkins. Finley noted that the soil in the check dam areas, in most cases, was a rich, highly organic clay loam or fine sandy loam, which should have been adequate for excellent crop growth. His examinations indicated that the checks had been made and then repaired at a later date, as two types of deposited material were present in those found along Soda Canyon. The early builders exercised considerable judgment in the size of the material used for construction. Where the grade was unusually steep, large, heavy, flat rocks were employed, while small, flat boulders were used on the more level portions of each area. It is not surprising to find that portions of most of the checks have been washed out, but since no maintenance work has been done upon them for at least 640 years, it is remarkable that a large portion of many checks is still in place.

Examinations showed definite indications of probable water diversion from the flood water ditch onto both of the Soda Canyon check-dam areas. It is, therefore, clear that the flood water supply ditch would have played an important part in making good the deficiency of moisture on the lower part of the mesa when heavier precipitation occurred at higher elevations.

The best evidence which can be obtained as to the crops grown at Mesa Verde is furnished by the excavations of Fewkes at Spruce Tree House and Cliff Palace, in which he has recorded the materials found in food caches. The buried foods consisted of corn, beans, squash, pumpkin and gourds. Fewkes also found wooded planting sticks similar to those used by the present-day Hopi, at both locations on Mesa Verde. This makes it probable that agricultural meth-

ods similar to those of the Hopi and Zuni were followed in early plantings on the plateau. Balls of raw cotton yarn or wicking, as well as cotton string with feathers wound around them, have been reported from the ruins. More of these cotton materials have been reported from ruins south of the Mancos River than from those north of this point. Well-woven cotton cloth has also been found by Fewkes at both Spruce Tree House and Cliff Palace, but no caches of cotton seed have been reported.

The writer has discussed the possibility of growing cotton at Mesa Verde with several cotton specialists of the Department of Agriculture. Studies have been made by Dr. T. H. Kearney of native Hopi cotton, which is still grown for ceremonial purposes near the Hopi villages at the present day. The Hopi cotton has been found to have a shorter growing period than the usual agricultural varieties, and it is not impossible that an earlier maturing strain might have been isolated from Pueblo cotton varieties, by careful hand selection, choosing the plants which blossomed and matured earliest in the fall. A study of the frost-free period at Mesa Verde shows a notable variation in the date of the last killing frost during the last 16 years of available records. In two years it was as early as April 8, but in two other

—*Stewart*

CLIFF PALACE, THE MOST EXTENSIVE VILLAGE AT MESA VERDE

THE HOUSES AND KIVAS ARE SO COMPLETE THAT THE RUIN APPEARS READY FOR OCCUPANCY.

years it was as late as May 23 and 29. This indicates it would have been difficult for a cultivator to take advantage of the full frost-free period, which has ranged from 146 days in 1924 to 197 days in 1936. In view of the great variability in the frost-free season, it seems probable that the cotton fiber and cotton cloth reported by Fewkes were acquired by trade from neighbors to the south.

In addition to the length of the frost-free period at Mesa Verde, the amount and distribution of the rainfall is of prime importance. The annual precipitation for the 17 years of available records, at the Park Headquarters, has averaged 21 inches. This total is higher than that recorded at Cortez in the Montezuma Valley or for any of the stations in the Navajo country to the south. Durango is the only station in this general region with approximately an equal rainfall amounting to 19.8 inches for a 44-year period. Although the amount of water falling on the mesa in recent years is greater than at many other points in this part of the arid Southwest, the distribution of the rain is irregular during many years and in ten years out of seventeen has been deficient or entirely lacking during June. This is the month in which corn would probably be planted and points to a need for supplementary water during the early growth of crops. Although the deficient June precipitation constitutes a major agricultural risk there is some compensation from the fact that there has frequently been excellent rain during late July, August and September.

The best picture of rainfall variations in early times is probably obtained from the tree ring studies of Douglass[1] at Mesa Verde. He has shown that alternations of wet and dry weather occurred in the past, but a long period of drouth started

[1] A. E. Douglass, *Nat. Geog. Mag.*, 56: 737-770, 1929.

—*Stewart*

NAVAJO CORN FIELD NEAR CHAPIN MESA IN MESA VERDE PARK

WHERE A FAIR CROP WAS MATURED IN 1939, AFTER A DRY YEAR, USING INDIAN PLANTING METHODS.

about 1276 A.D. and continued until 1299 A.D. This abnormal condition apparently wiped out all food reserves of the early inhabitants and caused the complete abandonment of the plateau. In this connection it is important to remember that the small ears of corn found by Fewkes in the Cliff Palace and Spruce Tree House ruins may have been raised during the last drouth period and so may not represent the normal size of ears produced with adequate rainfall during the time of early settlement.

The studies made at Mesa Verde indicate an integrated system of agriculture on one portion of the plateau which shows an unusual organizing ability upon the part of the primitive cultivators. An excellent trail dating from early times is still in existence between the Far View group at the head of the ditch and Spruce Tree House near its lower end. It would have been extremely easy for a runner to have given warning to the residents below that flood water was beginning to come down from the upper mesa when rainfall occurred which produced run-off, in order that the cultivators might come out and assist in the distribution of the water to the corn fields and check dam areas. Such evidence of an organized layout of supply ditch, corn fields and check dam gardens would either point to the presence in this part of Mesa Verde of an unusually able group of primitive cultivators and engineers, or else may indicate a general pattern of agricultural development of a relatively high order for a primitive race upon the entire plateau. Further study will be necessary to determine which of these possibilities is applicable.

Water conservation was evidently the principal purpose of the Mummy Lake reservoir and flood water ditch system down Chapin Mesa. The choice of the ditch cross section, however, was extremely effective in avoiding excess wash-

—*Stewart*

GENTLY SLOPING WATER-RETAINING BOULDER DAMS
ON THE MESA NEAR PECK'S WASH, 2.8 MILES FROM PIMA, ARIZONA, USED FOR EARLY AGRICULTURE.

ing and channel cutting. In the check dam garden plot areas, which were partly located upon solid bed rock, there is considerable evidence that planned soil conservation to retain soil for the house gardens was as much the purpose as was water saving. The two types of practice blended together, and it is safe to say that the check dam gardens form one of the earliest groups of American soil and water conservation demonstrations which can be definitely stated to date back to 1300 A.D.

A study of the available records of precipitation indicates that in most years Mesa Verde has been better supplied with rainfall than other places to the west and south. This has amounted to about six and a half inches more moisture than has fallen at Cortez and approximately twice the average for Chaco Canyon and Aztec. The deficient precipitation of June is also one of the risks to which crops are exposed in many places of lower average rainfall. Hence, the excellent rains of late July, August and September have meant that corn was likely to mature on the plateau unless a major drouth occurred such as that which probably wiped out the early settlements. Recently a demonstration corn field has been planted each year by the Navajos at the park on an area which receives some local run-off and is located near Chapin Mesa. Corn crops have been matured even after relatively dry years, when planted by methods similar to those used by the Pueblo Indians.

The relatively favorable agricultural conditions found at Mesa Verde probably increased the risk which the early cliff dwellers had from attacks by their enemies during years of partial failure around them, and point to one reason for their making their homes in the cliff-side refuges.

—*Stewart*

PRINCIPAL RUIN AT CASA GRANDE, ARIZONA

PROTECTED BY A MODERN ROOF AGAINST WASHING BY RAIN. THE VILLAGE AT CASA GRANDE WAS THE CENTER OF A COMMUNITY OF EARLY IRRIGATORS.

—*Stewart*

VILLAGE OF WALPI, LOCATED ON FIRST MESA
ONE OF THE OLDEST OF THE HOPI COMMUNITIES.

—*Stewart*

FLOOD WATER FIELD, HOPI, FIRST MESA
RECEIVING RUN-OFF FROM UPPER LAND.

—*Stewart*

CORN DRYING IN THE YARD OF THE GOVERNOR'S HOUSE AT WALPI
PART OF THE SHORT HARVEST OF 1939.

Pueblo Agriculture in the Upper Rio Grande and Gila River Valleys

A survey was made of present-day agricultural methods in the villages along the Rio Grande from Acoma to Taos. Planting, cutivation and irrigation have, in most cases, been greatly affected by the irrigated agriculture learned from the Spaniards so that it is difficult to find many examples of Indian cultivators who follow the old Pueblo practices unchanged as they may often be seen in the Zuni and Hopi country. This is not surprising when we read in the account of Oñate's settlers in 1598 that the expedition reached Santo Domingo on July 7, and on August 11 work was started on an irrigation ditch with 1,500 Indians helping.

Examination of the fascinating ruins of Puye and El Rito de Los Frijoles showed little evidence of early agricultural use that is definitely related to pre-Spanish cultivation around either site.

Along the Gila River a number of interesting examples of water detention structures were noted. One of these, located on the bench above Peck's Wash some 2.8 miles from Pima, Arizona, was examined intensively by John Cole, Soil Conservation Service, and the writer. On this area somewhat over 25 acres is laid out, with simple water detention boulder dams forming a complete spreading system. In the upper portion of the tract the detention structures were roughly rectangular in shape, varying in size from 8 by 10 feet up to 24 by 30 feet. At the present time there is no evident source of water for this group of farm plots, though it appears probable that the entire course of the surface drainage has been changed by an early washout. In the lower part of the area a definite system

—Stewart

WATER DETENTION BOULDER CHECKS AT SHUCKING RANCH
NORTH OF SELIGMAN, ARIZONA.

of terraces had been laid out on a grade of 2½ to 3½ per cent. The terraces ranged from 14 to 18 feet in width and extended from 180 to 225 feet long.

Deadman's Gulch and adjacent canyons across the Gila on Graham Mountain were found to contain a different type of garden site. Here a primitive style of terrace had been built, largely by clearing the land of loose boulders and piling them on the outer edge of the terrace bank. In places simple boulder water detention dams had been put across the stream to check the force of the flow. Portions of this area, examined by Dr. Emil Haury, were dated for the probable period of occupancy, by pottery shards, at A.D. 1200–1400.

Another use of boulder detention dams was studied in the Cañada del Oro, about 17 miles from Tucson, Arizona. Here single lines of larger boulders have been used for water detention on a tract of over 30 acres. In many cases the boulder dams were spread in a series of checks across a field at intervals of 10 to 25 feet, between the detention checks. The channels which would have carried water from one check to the next lower structure were often stabilized with boulder checks to prevent washing. The layout of the checks on this tract, as well as on the extensive tract at Peck's Wash, suggests that the primitive irrigators would have needed to get out on their fields during times of run-off to guide the water from one series of checks to the next and alter the supporting boulder walls as conditions showed were necessary to secure an even distribution of water.

In the lower part of the Gila River Valley, near the ruins of Casa Grande, and in the Salt River Valley adjacent to Phoenix, some remnants of the most ex-

—*Stewart*

GRAND CANYON FROM DESERT VIEW ON THE SOUTH RIM

ACROSS THE NORTH RIM, WATER DETENTION CHECKS SIMILAR TO THOSE FOUND AT THE SHUCKING RANCH HAVE BEEN REPORTED.

—*Stewart*

GRAND CANYON FROM MORAN POINT, LOOKING TOWARD NORTH RIM

WHERE PRIMITIVE WATER DETENTION CHECKS HAVE BEEN REPORTED.

tensive primitive irrigation systems in North America can still be found. These areas of early Pueblo culture, known as the country of the Hokokam, have been variously estimated to have embraced from 100,000 to 250,000 acres of irrigated land. In the development of modern systems of irrigation most of the early ditches have been plowed up and obliterated. The writer devoted some study to portions of the early Indian Salt River system which has been mapped by O. A. Turney. The parts of the ditches examined lay north of Phoenix, just below Pueblo Grande, where at least four separate ditches were diverted from the river in the direction of the former Indian settlement known as Casa Buena and La Ciudad. The distinctive feature about these canals was the fact that they were dug by hand and had a relatively flat gradient. Portions of the banks gave some evidence of possibly being lined with clay which may have been hardened by fire before water was used in them continuously. Since all the Hokokam settlements were abandoned before Spanish settlement, it is impossible to say whether this irrigation system was used to supply flood water to land where the water would be impounded and allowed to soak in, or whether irrigation was applied continuously during the growth of the corn crop. The principal interest of this paper is in the methods used under the more rigorous conditions found in the more arid portions of the Pueblo country, hence no attempt will be made to treat of the evidence of agricultural practice with a relatively assured water supply.

In the northern part of the Salt River Valley, near Cave Creek, a striking example of a self-contained agricultural community was studied. This was the so-called Fort Mountain site illustrated in Fig. 5. The main portion of the village was located north of the large hill. On the top of this eminence, rising some 500 feet above the surrounding country, was a refuge fort with walls 4 to 5 feet high and some 4 feet thick, made from piled-up boulders. A relatively wide flat diversion ditch for flood water ran from the adjacent creek to a tract of some 30 to 40 acres of corn land which would have been adequate for village needs. In addition, a number of boulder, walled, house garden patches were located on the south of the main hill. By means of these

FIG. 5. MAP OF FORT MOUNTAIN SITE NEAR CAVE CREEK DAM, ARIZONA

check dams, flash run-off could have been retained so that crops of beans, squash, early corn or cotton could have been grown. At first glance it appeared that the village should have been placed nearer to the agricultural area, but it was later discovered that the best trail up to the fort lay on the village side of the hill. Upon reaching the fort, the entire cultivated land, as well as the village, could be easily watched so that

human foes or destructive animals could be detected. Pottery shards dated the occupancy of the village at from 1000 to 1200 A.D.

Early Sites from Phoenix to the Grand Canyon

A series of primitive village locations extending north from Phoenix, including sites on New River, Upper and Lower Alkali Wash, Agua Fria Canyon, Bishop Creek, Hackberry Wash, five sites in Lonesome Valley, northeast of Prescott, one large area near King's Ranch Pueblo and a group of ruins north of Seligman were all studied and evidences of early agriculture were found. In the majority of these village communities a group of small garden plots partly terraced on a gentle slope, with stabilizing rows of boulders at the outer edge, were found close to the village. The main dependence for such gardens was upon local run-off. In two cases, however, entire fields at King's Ranch Pueblo and Shucking Ranch north of Seligman were laid out with water detention boulder checks to insure success of the corn crop.

Preliminary examinations at the Grand Canyon National Park indicated that agriculture was practiced on the plateau adjacent to the north rim, while cotton seed found by the park staff in small ruins adjacent to Bright Angel Trail, points to the growth of this plant in gardens in the lower parts of the canyon. It is hoped to make more detailed studies in both locations at a later date.

THE HEAT OF THE SUN

After stating the probability that, if sunlight was ready, the earth was ready both for vegetable and animal life within a century, or at least a few centuries, after the consolidation of the earth's surface, Lord Kelvin inquires whether the sun was ready, and replies:[1] "The well-founded dynamical theory of the sun's heat carefully worked out and discussed by Helmholtz, Newcomb and myself, says NO if the consolidation of the earth took place as long (ago) as 50 million years; . . .

Here is an unqualified assumption of the completeness of the Helmholtzian theory of the sun's heat and of the correctness of deductions drawn from it in relation to the past life of the sun. There is the further assumption, by implication, that no other essential factors entered into the problem. Are these assumptions beyond legitimate question? In the first place, without questioning its *correctness*, is it safe to assume that the Helmholtzian hypothesis of the heat of the sun is a *complete* theory? Is present knowledge relative to the behavior of matter under such extraordinary conditions as obtain in the interior of the sun sufficiently exhaustive to warrant the assertion that no unrecognized sources of heat reside there? What the internal constitution of the atoms may be is yet an open question. It is not improbable that they are complex organizations and the seats of enormous energies. Certainly, no careful chemist would affirm either that the atoms are really elementary or that there may not be locked up in them energies of the first order of magnitude. No cautious chemist would probably venture to assert that the component atomecules, to use a convenient phrase, may not have energies of rotation, revolution, position and be otherwise comparable in kind and proportion to those of a planetary system. Nor would he probably feel prepared to affirm or deny that the extraordinary conditions which reside in the center of the sun may not set free a portion of this energy. The Helmholtzian theory takes no cognizance of latent and occluded energies of an atomic or ultra-atomic nature. A ton of ice and a ton of water at a like distance from the center of the system are accounted equivalents, though they differ notably in the total sum of their energies. The familiar latent and chemical energies are, to be sure, negligible quantities compared with the enormous resources that reside in gravitation. But is it quite safe to assume that this is true of the unknown energies wrapped up in the internal constitution of the atoms? Are we quite sure we have yet probed the bottom of the sources of energy and are able to measure even roughly its sum-total?—*Thomas Chrowder Chamberlin, in a reply published in "Science" on June 30 and July 7, 1899, to Lord Kelvin's address at the Victoria Institute in 1897 on "The Age of the Earth as an Abode Fitted for Life," published in "Science" May 12 and May 19, 1899.*

[1] *Science*, May 19, 1899, p. 711.

ANTIDOTES FOR SUPERSTITIONS CONCERNING HUMAN HEREDITY

By Dr. KNIGHT DUNLAP

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SOME thirty years ago the Kallikak family was boosted into an unfavorable notoriety, and shortly became a great asset to propagandists for eugenical sterilization and other nostrums. Even in books written by psychologists who ought to know better, the Kallikaks skulk in the corners of the pages, and leap out upon unwary students.

The fame of the family began with an anecdote perpetrated with incredible innocence by an eminent expert on "intelligence," and repeated with astonishing solemnity by many after him. The anecdote concerned the unblest union of a Revolutionary soldier with a feeble-minded girl, from which sprang a long line of descendants who were feeble-minded and prone to epilepsy, alcoholism, prostitution and what have you. I have often told this story to classes, and waited to see how many students would raise the obvious question: How do you know the girl was feeble-minded? Did anybody test her and assign an I.Q.? What is the evidence? Of course, there is no evidence. The promoter of the legend inferred that the girl was feeble-minded because she had feeble-minded descendants. Then, from the assumption of her feeble-mindedness he inferred the fatal heredity of amentia. This procedure, of assuming the conclusion in the premises from which it is presumably drawn, is called by the logicians, "Begging the question."

The Kallikak phantasy has been laughed out of psychology, along with the even more appalling legends of the Nams and the Jukes; but the theories involved in them still linger in popular superstitions, endorsed by many writers of supposedly scientific books, along with other popular beliefs about heredity, and do definite damage to young persons who take the theories seriously. Many of these young persons fear to marry, lest their children should be feeble-minded, since they think there have been feeble-minded persons in their families in past generations.

The fear of hereditary mental disease, played up by eugenicists and other fear propagandists, has driven many young men and young women into maladjustments, and even into suicide or neuroses. Almost every psychologist is familiar with these cases, some of which come to him for help. The great majority, however, do not know that help is possible.

Dr. Abraham Myerson, in his book reporting the findings of the committee of which he was chairman, has done excellent work in disemboweling the alleged evidence for the fatal heredity of mental diseases, but relatively few of the victims of the superstition will read the book, and those who do are apt to be misled by the summary of conclusions, which is not based on the analysis of the book itself, but appears to be a compromise between the real showings and the prejudices of committee members. Meanwhile, the propaganda for a stupid type of heredity for mental disorders goes on in popular and professional journals.

Psychologists find no difficulty in resolving the difficulties of neurotic or perturbed youngsters who seek their advice. For the benefit of the layman, it may be worth while to summarize the psychologist's procedure. In the first place, he points out that nothing is really known about human heredity, except that certain traits, such as red hair, haemophilia and Presbyterianism, "run in families." That for most traits, we do not know how they "run," the traits for which the

principles of inheritance are known, even vaguely, being very few. And that hasty inferences from traits of fruit-flies and potatoes to human traits has not been useful.

The psychologist, in the second place, will point out that the scare-data which has been assembled to prove the fatal heredity of mental diseases and of feeble-mindedness, has been gathered by the too-familiar method of selecting the data which agrees with one's theory while ignoring cases which would not support it. In regard to feeble-mindedness in particular, he points out that some of the data which impresses the public most was gathered by untrained persons, who were not able to tell whether an individual is feeble-minded or not.

In the third place, he points out that principles, or "laws" of inheritance for any trait, while they may possibly be developed for some simple physical traits, could hardly be expected for complex conditions, such as epilepsy and feeble-mindedness, until we know what the immediate causes of these conditions are; and that at present we do not know how many different abnormal conditions are lumped together in these waste-basket classes. It is useful, moreover, to point out that the mental disorders of which the causes are definitely known, namely, the organic psychoses, are not included in the group to which a fatal hereditary nature is ascribed by the pseudo-geneticists, who confine their scare propaganda to the disorders of unknown nature, such as feeble-mindedness, idiopathic epilepsy and the disorders in the other waste-basket which are called "dementia praecox" or, in flossier and more misleading terminology, "schizophrenia."

In these ways the psychologist emphasizes the fact that, for a person who discerns an occasional nut or two on his family tree, the chances that he will have a nut for a child are, *so far as is now known*, no greater than for the person who doesn't happen to find any nuts on his tree. For the young man who is convinced, on the basis of popular heredity doctrines, that he is going insane, the relieving conclusion is as obvious.

The frightened young persons of whom I have been speaking are, of course, not themselves feeble-minded, or mentally "diseased," although some of them are temporally neurotic because of their fear of the fell effects of heredity. The feeble-minded and the deranged would not be advised to marry for practical reasons not connected with the superstitions concerning heredity; the neurotic are advised to do something about their neuroses before planning to marry. In every case, the patient is assured that the problems of heredity are of great importance, but he is reassured that the scientific problems are far removed from the superstitions which are troubling him.

In some cases of perturbation or neurosis induced by superstition masquerading as science, I have found it well to go a little further, and discuss superstitions concerning the heredity of traits not connected with the particular problems of the patients. Among these traits, which in many cases are not causes of worry, are eye-color, color-blindness and deafness. In some cases, of course, superstitions regarding these are important sources of perturbation.

The eye-color doctrine is familiar. There are two classes of eyes, often called "blue" and "brown," other colorations being ignored. The ignoring of green, red and violet colorations, however, is sometimes a little strong for the pseudo-geneticist to swallow, so he classes eyes simply as "light" and "dark." The inheritance of the two colors is put on a simple Mendelian basis. Blue is recessive, brown is dominant. As a consequence, it is not lawful, in the Mendelian sense, for the child of two blue-eyed parents to have brown eyes. The number of brown-eyed children who, through the taunts of companions or their own imbibing of pseudo-science, have been made

miserable by the suspicion that they are illegitimate, or what is often as bad, adopted children, is larger than the layman might suppose.

The eye-color superstition is of origin somewhat less ancient than the superstition concerning feeble-mindedness. Put forward in a simpler form at first, with the rising tide of Mendelianism it received its present shape, and was so generally accepted that only recently has it begun to be eliminated from text-books. Genetic studies of eye-color inheritance were made without the careful examination of any eyes. Of course, the data were probably selected, for even on casual examination of eyes many disturbing cases appear; but these can be treated as "anomalies." Actual study of eyes shows at once that eye-color, in a mixed population, such as that of the United States or European countries, is not an "all-or-none" matter, but the colorations of the iris are mosaic patterns involving usually more than two colors. Eyes classified as "blue" on casual examination often show, when really examined, greater area of brown in the iris than of blue. The brown-eyed child who is worried about his parentage can resolve his doubts easily by examining the eyes of his putative parents with a good reading glass in good daylight. This procedure, one might suspect, would be unfortunate if the child were really adopted or his mother had been indiscreet. There is no reason for concern here. Eyes are mixed so generally that the chances that the brown-eyed child will not find some brown areas in the eyes of his putative parents are so small as to be negligible.

Superstitions concerning inheritance of color-blindness seldom produce neuroses. They are illuminating, however, in conjunction with the more deadly superstitions. The sex-linked color-blindness, described by pseudo-geneticists usually as an all-or-none trait, is most interesting; but psychologists have not been able to discover this sort of color-blindness. Nature, or the Creator, seems to have been unable to supply what the theorists need. The color-blindness we know, is a matter of great complexity of variation, shading from slight color-weakness to extreme protanopia and deuteranopia with other forms not as yet fully investigated. In some cases, it "runs in families"; sometimes, indeed, appearing to crop out in grandfather and grandson, skipping the intermediate mother. In other cases, it appears to crop out in grandmother and granddaughter, skipping the intermediate father. It appears, too, in father and son and mother and daughter, as well as in father and daughter and mother and son. The apparent "skips," moreover, can not be taken as certain in all reported cases, for the popular tests for color-blindness are highly unreliable, and in many cases only the persons under suspicion have been tested. The popular theory of the innate nature of the defect has been somewhat demoralized by the discovery of cases which are normal in color vision in early adolescence and typical deuteranopes a year or two later. From case histories of persons who "suddenly" discover, in the late teens, or later, that they are color-blind, we have reason to suspect that there are many cases of this kind. As for the causes of color-blindness, while we may suspect that in all cases it has a toxic or other chemical basis, as it certainly has in some cases, we are still lacking in knowledge; but we would, to-day, hesitate to say that it is incurable.

Investigations into the heredity of traits concerning which the investigator is uninformed, and which he would not know how to identify, are the outstanding sources of misinformation and support of superstitions regarding color-blindness, eye-color and feeble-mindedness. It is not without interest that the one field of heredity study in which the investigator is expected, first of all, to be able to diagnose the trait he studies, and to be well grounded in regard to it,

is the field of cancer; and that it is in this field that jejune conclusions are least conspicuous.

There is one more doctrine of pseudo-genetics which, although exploded so far as science is concerned, is still popular and is still a source of perturbation and unhappiness, although, so far as I know, not a cause of neuroses or suicides. This is the doctrine that a person who is congenitally deaf is especially apt to procreate deaf children; and that the mating of two congenitally deaf persons is almost certain to result in deaf children, if any.

To a person worried lest his defect of hearing would be transmitted to his offspring, and hesitating to marry on that account, it is necessary to explain that cases of actual congenital deafness are few, and that there is only one type of deafness which is "hereditary," in the popular sense of the term, and that form, in which cochlea fails to develop, is rare. If there is a "hereditary" disposition towards contracting measles, scarlet fever, diphtheria, colds in the head and the other actual causes of deafness, that is another matter. The selected cases in which deafness "runs in the family" are no more significant than the cases of vegetarianism or poverty, which also "run in families."

The problem of deafness and its inheritance furnishes also an approach to the method of clearing up the difficulties of persons who have become impressed by the studies in which there has been an attempt to get at the "hereditary" factor in intelligence by correlating the intelligence of children with that of their parents through a simplistic use of intelligence scores. The "intelligence" which intelligence tests measure is, of course, not the same as the "intelligence" which is supposed to be inherited; and an inference from the first to the second can be made only on the basis of a vastly greater fund of information than the intelligence test scores supply. Aside from this, however, there is the fact that a trait which superficially appears to be "inherited" in a simple way may be a resultant of more fundamental traits, which, indeed, are inherited, but in a complex way. Thus, deafness may be a result of one of a number of different causes; such as scarlet fever, "colds" invading the middle ear, and so on. There may possibly be "inherited" susceptibility to one or another of these diseases, and so, indirectly, deafness may be "hereditary." Or, there may be "inherited" tendencies on the part of parents to neglect these diseases in children. The whole matter, however, is put on a different basis if we look at it from this point of view.

That feeble-mindedness in different individuals has different causes is entirely possible. Some of these causes may be hereditary in the way in which eye-color is (whatever that way may be). The heredity of others may be like the heredity of Presbyterianism. Until we know something of the approximate causes of feeble-mindedness, worrying about its mode of inheritance is fruitless.

Some of the traits, defects and diseases which 60 years ago were agreed to be "inherited" in the popular sense of the term have to-day dropped out of the picture. Thus, Darwin said in 1876: "Striking instances have been recorded of epilepsy, asthma, stone in the bladder, cancer, profuse bleeding from the slightest injuries, of the mother not giving milk, and of bad parturition being inherited."[1] To-day, haemophilia is admitted to be transmitted in families in a rather simple way; epilepsy is believed by some to be similarly "inherited"; the verdict on cancer is "not proven"; but "consumption" is no longer listed, because the primary cause of tuberculosis has been found. It is entertaining to note that Darwin quotes Dr. Garrod as saying that 50 per cent. of the cases of gout observed in hospital practice are "inherited." When the causes of traits

[1] "Animals and Plants under Domestication," Chapter 12, 451–2.

defects and disorders are discovered talk about the "inheritance," as simple entities, of most of them, ceases abruptly. The real problem of heredity is not done away with, however, but is revealed as so complex that its principles have little in common with the popular doctrines handed down from the past.

The retailing of case histories is boring and unimpressive, but one case recently in my hands is so illustrative and so entertaining that it merits description. A college girl came to me for advice as to the method of committing suicide which would be least distressing to her family. She did not want advice as to whether or not to kill herself; she had decided that point. This was probably an overstatement, but that was her story.

In applying the routine technique for would-be suicides, I told her, of course, that suicide is often a good thing, but that the persons contemplating it are usually in no mental condition to make the decision, but need expert and disinterested advice. That, if her reasons for suicide were good, as they might be, I could indeed help her select an adequate method. She was reluctant to give her reasons, but finally came through. She was, she said, developing manic-depressive insanity. Her condition was becoming worse, and would, obviously, in the course of time be a great cause of shame and other trouble to her family, from whom, so far, she had concealed the facts. So, it was clear that she should commit suicide in the least flagrant way, before her mental condition should become too evident to be concealed.

On questioning her as to the evidences for her manic-depressive condition, I found that she had earlier taken a widely used test, which may conveniently here be classed as a "personality test," the results of which showed that she was of a manic-depressive type. I should say that the test was taken before entering the university, for we do not administer such tests except for illustrative purposes, with full explanation that the results are not to be taken seriously.

From this start in fear, the girl had commenced to read up on manic-depressive insanity, and, since she had not had a protective course in abnormal psychology, she discovered that she had the symptoms, as might be expected. From her reading also, she found that the disease is hereditary; and she found in her family tree one or two cases of what she *believed* was mental disease. In her perturbation, her symptoms of course became worse, and so the stage was set for suicide. Having courage enough, and self-sacrifice enough, to face suicide, she had not developed a serious neurosis.

It was not difficult to convince the patient that the test which started her into trouble was silly and that the doctrine of the inheritance of mental disorder, as she had learned it, was a myth; that her chances of going insane were no better than my own, or those of seven thousand of her fellow students. This treatment was effective. If the girl had been psychoanalyzed, or advised by an inexpert "psychologist," her chances would have been small for readjustment, if I may judge by other cases.

In summary and conclusion, I must insist that at the present time one of the major duties of psychologists, in the service of society, is to combat the popular superstitions about human heredity; to point out that while all human traits, without exception, are hereditary in the modern scientific sense of the term, we know nothing, as yet, about the modes or details of inheritance of important traits. It is our duty, further, to explain in detail the complete lack of scientific foundation for the popular theories, which, unfortunately, are still endorsed by some text-books. In this way, we can assist the prophylaxis against the most damaging of the superstitions.

MILESTONES IN METEOROLOGY

By WILLIAM HOLMES WENSTROM

MAJOR, U. S. ARMY (RTD.); FORMERLY WEATHER OFFICER WITH THE U. S. AIR CORPS

I

THE beginnings of meteorology, like the beginnings of most science and art, go back to the enlightened men who talked and walked and thought in the ever-varying alternations of warm sun and sea change that bathed the golden isles of Greece. Many of their thoughts in those early days were wide of the mark; but some have come down to us, and stand to-day as valid as they ever seemed of old. The Greeks made regular weather observations of a sort, principally of wind direction, as early as the fifth century before Christ. They introduced the eight cardinal wind points that are still used to-day—northeast, east, southeast, south, southwest, west, northwest and north. In the fifth century before Christ, also, Anaximander of Ionia defined the wind as "a flowing of air," which simple statement has never been improved upon since.

About 350 B.C. Aristotle, greatest philosopher of the ancient world, published four books under the general title "Meteorologica," meaning "the things above," and including phenomena astronomical as well as atmospherical. From the Greek word for "high in the air," also, grew our present name for the science of weather and climate—"meteorology." But if I may digress for a moment, "me-te-or-o-lo-gy" is, it seems to me, a clumsy word to spell and pronounce (to say nothing of that linguistic monstrosity "me-te-or-o-lo-gi-cal"), and somewhat too connected with meteors in the minds of laymen. If the inertia of long-continued and wide-spread usage could be overcome, it might be replaced by some more suitable term such as "aerology" or "atmology."

In Aristotle's treatise, at any rate, about one third of which was devoted to the science of the atmosphere, many weather questions were considered—the formation of fog and clouds, dew and frost, rain and snow and hail, theories of winds, thunderstorms and whirlwinds. The whole work was marked more by powerful imagination than by scientific method. Yet it was the earliest comprehensive work on meteorology, and remained for fifteen centuries the best. Theophrastus, one of Aristotle's disciples, also wrote a treatise on wind and weather which included some weather omens not unlike those that find credence to-day.

In ancient times life was leisurely and new developments came slowly. Rain, always vital to husbandry and farming, was the first weather element to be accurately measured. (Such measurement requires, indeed, nothing more complicated than an open bucket and a ruler.) As early as the first century A.D., rainfall measurements were made in Palestine, and the resulting rainfall records were preserved among the Jewish religious writings. Much later, by 1450, rain gauges were in use by the Koreans of China. But in the middle ages the frontiers of weather knowledge were already widening in another direction. During the eleventh century some Arabian astronomers, watching sunrise and sunset in the clear air of the Eastern desert, made the first rough estimate of the height of the upper atmosphere. They deduced from the duration of twilight that the earth's air extends in appreciable density to heights around fifty miles, and later experiments have confirmed their findings.

II

If meteorology may be said to have dawned in ancient Greece, its sun really rose in the sixteenth-century Tuscany of the Medicis. For weather work began to assume some dignity as an independent science when quantitative measurements of its several elements became possible; that is, when accurate weather-measuring instruments appeared. The first of these (aside from the rain gauge), and one of the most important, was the thermometer. Back in the third century, Philo of Byzantium and Hero of Alexandria had devised some primitive thermoscopes. The instruments themselves had probably no great value; but one of Hero's writings came, centuries later, to the attention of the first great experimental scientist—Galileo Galilei. He and his associates were to make northern Italy the cradle of instrumental meteorology and instrumental physics.

In 1592 Galileo, then at the University of Padua, constructed the first practical thermometer. Bearing small resemblance to the modern instrument, it consisted of a large bulb filled with air which, by its expansion when heated, forced downward the water level in a glass tube. Later, Galileo is thought to have devised, in essence, the modern thermometer—a small glass bulb of liquid free to expand into a sealed capillary tube. (The liquid was alcohol, still used in many modern instruments.) Thermometers of this type, at any rate, were used around 1640 by Ferdinand II, Grand Duke of Tuscany. Around 1720, Gabriel Daniel Fahrenheit started using mercury as a thermometer liquid, and devised the Fahrenheit scale that is still in ordinary use among all the English-speaking peoples. And about 1742, in Sweden, Anders Celsius devised the centigrade scale that is in universal scientific use to-day.

In 1640 also, the same Ferdinand II of Tuscany, one of the most enlightened of the later Medicis, entered the march of knowledge by ordering that a deep well be dug near Florence. Such an ordinary action might at first glance have been thought free from future scientific implications; yet it was found, to the surprise of all, that water would not rise in the well pipe, even when the air was drawn out of it, to a height greater than about 32 feet. Galileo, consulted near the end of his life's labors, judged that "nature's abhorrence of a vacuum," until then thought absolute, appeared to have limits. Before his death he suggested that liquids of different densities should rise to different heights in an evacuated tube, and passed the problem on to his pupil, Evangelista Torricelli.

Torricelli put the experiment on a more convenient scale by adopting mercury, the heaviest of all liquids, which rose about 30 inches in an evacuated tube. He then concluded that, in the words of Millikan and Gale, "the rise of liquids in exhausted tubes is due to an outside pressure exerted by the atmosphere on the surface of the liquid, and not to any mysterious sucking power created by the vacuum." Torricelli proved this by placing his whole barometer in a bell jar and pumping out the air, whereupon the mercury column sank in the barometer tube. Torricelli's barometer, unchanged in general principle though considerably refined in form, is used for all accurate pressure measurements to-day.

Barometry now moved by leaps and bounds. In France, Blaise Pascal reasoned that air pressure, like pressure in other fluids, should diminish as one goes higher in the atmosphere. Lacking a mountain on which to try the experiment, he wrote his brother-in-law Perrier in the south of France. In 1648 Perrier carried a barometer up a sizeable mountain (Puy de Dome) and was "ravished with admiration and astonishment" when he found

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the mercury column sinking in the tube. The surveying aneroid and the airplane altimeter were now possible. In addition, the barometer was used to indicate daily small changes in atmospheric pressure, which before long came to be associated with weather changes; high pressure vaguely foretelling fair weather, and low pressure, foul.

The barometer and thermometer soon became, and still remain, the most important instruments in meteorology, but other developments followed fast. In 1653, that same Grand Duke of Tuscany, incidentally, whose well had started the whole barometer sequence, established several weather observing stations throughout northern Italy—the first weather network ever projected and the germ of modern weather-reporting services—and sought to establish also an international chain of stations.

Somewhere around 1667 men devised the earliest type of anemometer, giving the first numerical measure of wind strength; the device was merely a rectangular plate hung by one end so that increasing wind pushed it out to an increasing angle from the vertical. Rotating anemometers came into use by about 1724, and the instrument was further improved some fifty years later by the Swiss geologist, meteorologist and alpinist, Horace Benedict de Saussure. Saussure also pioneered much of the early work in moisture measurement; and he invented the hair hygrometer, which indicates the relative moisture of the air in simple and direct fashion by virtue of the fact that a strand of hair expands when it is moist, contracts when it is dry.

III

The great trade winds of the tropics had been known and used for centuries before any one sought rationally to explain them in the light of known facts. In 1686, Edmund Halley, soon after calculating the orbit and predicting the return of his seventy-year comet, published in England a paper entitled, "An Historical Account of Trade Winds and Monsoons Observable in the Seas Between and Near the Tropicks, with an Attempt to Assign the Physical Causes of the Said Winds." Halley rightly concluded that monsoons—winds blowing alternately from sea to shore and shore to sea—were caused by the temperature differences between land and water. He also demonstrated that the sun's heat near the equator was the primary cause of the trade winds. But he overlooked one very important factor in the winds of the world, which another Englishman, George Hadley, discovered in 1735. This factor is the deflective force due to the earth's rotation, which causes the southward-drifting trades to turn west, and leads the northward air drifts in temperate latitudes to turn east.

Around 1850, Heinrich Wilhelm Dove, one of the greatest of all meteorologists and climatologists, brought out in Germany his celebrated book on the "Law of Storms." He tried to give a fuller explanation of the great wind systems of the world, postulating two main circulations in each hemisphere: one between the equator and the tropics, the other between the tropics and the pole. He studied keenly the origin of large-scale storms—the cyclones or "lows" of temperate latitudes—and concluded that they were due to the continual strife between tropical air currents flowing up from the south and polar air currents flowing down from the north. This early idea of Dove's is, as we shall see, the germ of modern weather analysis methods that have recently revolutionized temperate-zone aerology.

Around 1850, too, Matthew Fontaine Maury of the U. S. Navy made his famous researches into the prevailing winds of the seven seas. Maury finally prepared complete charts of these winds, and by using his charts, sailing-ship

captains cut the time of long voyages by 25 per cent.

After Dove and Maury came many distinguished men, advancing theoretical meteorology in various particulars. William C. Redfield in America studied West Indian hurricanes and the storms of the Atlantic coast, finding that "a cyclone is constituted by a considerable mass of air endowed with a rapid movement of rotation in the direction opposite to the hands of a watch." William Ferrel, also an American, worked for many years on the problem of world air circulation, and published theoretical solutions that were accepted for some time. At the time of the American Civil War, Sir Francis Galton, working in England, wrote: "I have deduced . . . the existence not only of cyclones, but of what I dare to call anticyclones." And to-day, the anticyclone, or "high," is beginning to assume even more importance in modern weather forecasting than the traditional cyclone, or "low." In Holland, Buys Ballot framed his oft-reiterated law of pressure-wind relations: "If you stand with your back to the wind in the northern hemisphere, then the low pressure will be on your left hand"; and developed other important pressure field—wind field relations. Towards the turn of the century Hugo Hildebrand Hildebrandssen of Sweden and Leon Teisserenc de Bort of France revised Ferrel's theory of world winds, and in their "Fundamentals of Dynamic Meteorology" reduced all previous ideas of planetary circulation to the complete and unified theory that is generally accepted to-day.

IV

In the opening years of the nineteenth century the Chevalier de Lamark, working in France with Laplace, Lavoisier and others, established a network of weather stations and published a series of annual weather reports. Back in 1820, Heinrich Wilhelm Brandes, a German, had conceived a simple yet profoundly important idea. This was, in brief, that the wide-spread phenomena of the weather could best be studied by plotting on a map various weather observations taken at the same time, covering as large an area as possible. A year later William C. Redfield was drawing these synoptic maps of American weather conditions. But in those days, of course, the synoptic maps could not be made until slow mails had arrived from distant places—until the weather being studied had come, done its worst and gone.

In 1844 the first commercial telegraph clicked from Baltimore to Washington the devout message: "What hath God wrought!" At the same time men were suggesting, in various parts of the world, that the new electrical marvel be used to send weather reports from outlying stations in to control weather offices. But the first actual telegraphic weather reports were sent, also in the United States, in 1849 at the suggestion of the great electro-physicist Joseph Henry. He and James Pollard Espy (who had developed the convective theory of cyclones) organized the first regular weather service in the United States, now grown into our large, ubiquitous and immensely useful Weather Bureau. Like many another admirable American agency of peace, this weather project was born in our War Department; and the first official American weather forecasters were army officers detailed to that unaccustomed duty.

Espy and Elias Loomis greatly improved weather plotting methods. Under them the daily weather map grew towards the romantic tapestry it is to-day, showing at a glance all the morning's weather over the whole of North America from Alaska to Panama. Daily weather maps were introduced into England by Admiral FitzRoy, who in 1861

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hazarded a storm forecast that actually came true. Soon after, in France, the astronomer Le Verrier began publishing a daily, up-to-the-minute weather map. Meanwhile, FitzRoy, together with Siljeström and Lilliehöök in Sweden, confirmed and elaborated some of the storm theories of Dove.

V

The first upper air meteorological sounding was made by Dr. Alexander Wilson, a Scotchman, in 1749. He tied a thermometer to a kite and sent it aloft to measure the temperature at upper levels. During recent years a score of airplane pilots scattered over the United States, and perhaps another score elsewhere in the world, have gone aloft each morning with much the same idea in mind; for Wilson really started, unknowing, the whole modern, much-publicized program of "air mass analysis." About 1809, Thomas Foster began to use in England small balloons rising freely as a means of determining the winds at upper levels, watching their drift from a ground observing station. Thus began "pilot balloons," which now ascend uncomplaining each day at all hours and in all weathers from three score stations in the United States alone.

During the late eighteenth and early nineteenth centuries the free balloon was in its heyday, daily carrying men to various adventures and not seldom to disaster. The first temperature measurements of the upper air were made by the aeronauts Jeffries and Blanchard in 1784. Soon the balloon was in common use for atmospheric soundings. In the eighteen-fifties John Welsh, of England, made several ascents up to an altitude of about 20,000 feet (higher than sounding airplanes go to-day), observing pressure, temperature and humidity at all levels. At about the time of the American Civil War, Scientist Glaisher and Pilot Coxwell rose above watchful England in a series of atmospheric soundings that left little to be desired for thoroughness and accuracy. One of their twenty-eight ascents reached an astounding altitude (considering their preparation and equipment) of something like six miles. These intrepid pioneers, incidentally, also attempted the first aerial photography and dropped the first aerial bombs.

Toward the end of the nineteenth century self-recording instruments were developed which made it unnecessary for men to go aloft after meteorological data. The smaller sounding balloons, or balloon-sondes, could go far higher without discomfort—easily to altitudes around ten miles and perhaps to twenty. In addition to his theoretical work, Teisserenc de Bort pioneered in France and elsewhere these high-altitude, small-balloon soundings. In 1901 he discovered the stratosphere or isothermal layer—that still, frigid region where temperature stops decreasing with increasing height. De Bort sent up his balloons from various points in Europe and from his steam yacht in the south Atlantic Ocean. In Germany, Richard Assman also sounded into the stratosphere with self-recording instruments. In the United States, Abbot Lawrence Rotch, of Blue Hill, sent up many sounding balloons to great heights, and collaborated with de Bort in studies which showed the variation in height of the stratosphere base from pole to equator.

The latest development in atmospheric sounding is the "raysonde" or radio-sounding-balloon, a small robot which sends back word of pressure, temperature and humidity being encountered as it rises through the troposphere and into the stratosphere. The first raysondes appeared around 1925, and a standard instrument went into quantity production in 1938.

VI

The present inspiring phase of meteor-

ological progress, so far as we know it, began during the Great War. About 1893, it is true, Frank Hagar Bigelow, of the United States Weather Bureau, had developed his "counter current" theory of the origin of cyclones, amplifying the earlier ideas of Dove. Bigelow thought that the interchange of air between equator and pole takes the form of great currents of unlike air, flowing side by side. The northward-moving currents, of tropical origin, are warm and moist; the southward-moving currents, of polar origin, are cold and dry. Twenty-five years later U. S. Army weather forecasters with the American Expeditionary Forces in France used technique closely approaching modern physical weather analysis.

But chief credit for the systematic building of all these early ideas into the unified and workable whole of modern air-mass-and-front theory and practice must go to a few weather analysts in Norway. Their work reached practical importance around 1918, and continues at the present time. Three of them are from one lineal line: Carl Anton Bjerknes, the grandfather, began with theoretical hydrodynamics in the nineteenth century; Vilhelm F. K. Bjerknes, the father, applied hydrodynamical theory to meteorolgical theory; Jakob Bjerknes, the son, translated this theory into practical applications. Collaborating with the younger Bjerknes are others of the Bergen school—notably Halvor Solberg, Tor Bergeron and Sverre Petterssen. The new ideas have been heralded under a variety of names, of which "polar front theory" and "air mass analysis" are the most common. But more accurately descriptive, perhaps, are "air-mass-and-front analysis" and "physical weather analysis." Here again invention sprang from necessity, for in the World War of 1914–18 the Norwegians were cut off from outside weather reports, and hence had to analyze their local and regional weather more thoroughly and completely than ever before.

The Bjerknes "polar front picture" first appeared in 1918. During the winter of 1923–24, Vilhelm Bjerknes, just beginning to get reliable routine results at Bergen, came to the United States and lectured at several institutions; this was the first real inkling of air-mass-and-front analysis to reach America. In 1926 Carl-Gustave Rossby came from Norway to America and, failing to interest the Weather Bureau in the new theories at that time, went to Massachusetts Institute of Technology, where as professor of meteorology he has since made important contributions to the science. The new ideas did not appeal at once to every conservative meteorologist accustomed to other viewpoints, and in some quarters they were tacitly or outspokenly opposed. But their present sweeping progress leaves little doubt that they represent a truer and more complete system of viewing weather phenomena than has ever existed before.

VII

This air-mass-and-front analysis of the Norwegians is based in general on five main ideas, simple enough in themselves, but somewhat complex in their complete application. These basic ideas are:

1. When air stagnates for some time over a distinctive geographic area, called a "source region," it acquires characteristics, such as temperature and moisture, in keeping with the current climate of the source region. For example: "polar" air is relatively cold, "tropical" air is relatively warm, "continental" air is relatively dry, "maritime" air is relatively moist. In general these characteristics are not limited to air near the surface, but extend several miles aloft.

2. Impelled by the general atmospheric circulation, large masses of air (hundreds of miles across and several miles deep) may travel long distances over the earth's surface, still retaining in some degree their source region characteristics, which are modified only gradually as the

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air mass sojourns in a new geographic region. This modification is usually accomplished first at the surface, later aloft.

3. When two dissimilar air masses are brought together by the general atmospheric circulation they do not immediately mix; a definite boundary or discontinuity zone (perhaps five or more miles wide) occurs between them. Along and near the boundary colder (denser) air always underlies warmer (rarer) air in the form of a wedge; hence the "front" between the warm and cold masses (actually a mixing zone but pictured and spoken of as a discontinuity surface) is usually inclined at a small angle to the earth's surface.

4. Definite air mass interactions (producing variable winds, clouds, rain and other weather phenomena) occur along these fronts. The form and intensity of these interactions depend on the differences in characteristics of the dissimilar air masses involved, their extent, and the rapidity with which they are brought together.

5. In addition to this "frontal" weather, clouds, rain, and other weather effects may occur within air masses where the characteristics of the air mass itself favor them, and where terrain features and the motion of the air mass accentuate these characteristics.

It must be emphasized that air-mass-and-front analysis applies mainly to the temperate zones of the earth's surface. The tropics are under warm, moist, "tropical marine" air almost all the time, and this air varies in heat and moisture only slowly with the seasonal, north-south slow swing of the "apparent" sun. The arctics are likewise under fairly uniform cold, dry "polar continental" air most of the time. It is only in one of the temperate zones that a real "polar front" causes a continuous interplay of unlike air masses and large-scale cyclonic storms. However, the temperate zones in general, and the north temperate zone in particular, are where most of the world's people live, and where most of mankind's intellectual and material advancement is carried on.

Significant and revolutionary as the new air-mass-and-front analysis methods are, they have disproved no *physical* principles that came before them; nor will they. The wind is still "a flowing of air," as the ancient Ionian defined it. The rise of liquids in exhausted tubes is still due to an "outside pressure exerted by the atmosphere on the surface of the liquids," as Torricelli stated during the Renaissance. The large-scale storms of the temperate zones are still due, as Dove discovered when the United States was young, to the continual strife (now garbed in the nomenclature of air masses and fronts) between tropical and polar air currents. There is nothing absolutely new under the sun. But the world does move, and meteorology moves with the forward march of science.

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SKETCH OF THE DEVELOPMENT OF THE WATER CULTURE METHOD OF GROWING PLANTS

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THE history, development and use of the water culture and sand culture methods for the study of plants may be divided into four rather distinct periods: The first period began about 1700 and ended about 1800. The second period ended about 1860. The third period extended from 1860 to about 1900. The fourth period began about 1900 and continued to the present time.

The water culture of plants as it is known to-day probably had its beginnings in the work of Woodward[1] during the late years of the seventeenth century. Woodward grew several species of plants in different kinds of water: rain water, river water, spring water, conduit and distilled water, in an attempt to discover the so-called "principles of vegetation." He concluded that water is the carrier of "terrestrial matter" from which vegetables are formed, that earth, and not water, is the matter which nourishes the plants. This is the earliest record of experiments with water cultures. Following these early experiments with water as a culture medium other investigators of plants became interested, and prior to 1800 several series of investigations with water cultures are recorded. Thus Duhamel du Monceau,[2] in 1750, from the results of a comparative study of plants grown in soil and in water culture concluded that the plants in both cases had the same composition. This work was published in 1758. However, during this early period so little was known about the fundamentals of plant nutrition that there was small chance for any profitable outcome from such experiments, although during this period the conception of soil minerals as plant nutrients was developed. This paved the way for the extensive investigation of the assimilation of the ash constituents of plants carried out during the second period in the history of water culture development.

At the beginning of the second period, about 1800, some experiments with water cultures which had some real significance were carried out by de Saussure.[3] He investigated the absorption of certain salts by a variety of plants from various solutions. Some of his conclusions, at that stage in the history of water culture, had considerable importance and they were sometimes referred to as his "laws." He discovered that roots absorbed much more water than was required by the plant for nutritive purposes and that they extract much less of salt than of water from any given solution, and that all the salts in a mixed solution are not equally absorbed, thus laying the foundation for the concept of differential salt absorption by plant roots. He discovered also that roots absorb substances from solution regardless of whether these substances are essential in the metabolic processes of the

[1] J. Woodward, Phil. Trans. Royal Soc. London, 21: 382–398, 1699.

[2] H. L. Duhamel du Monceau, "La physique des arbes." Paris, 1758.

[3] T. de Saussure, "Recherches chimiques sur la végétation." Paris, 1804.

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plant or not, although Sprengel[4] was perhaps the first to assign specific importance to the essential elements, which he said could not be replaced by others, and to state specifically that not all the ash constituents are essential to the plant. This was a direct contradiction to the older view that roots had the power of selecting from the soil just those substances which the plant required and rejecting all others. The concept of differential absorption of ions from solution came as a much later development.

By the middle of the nineteenth century, sufficient information concerning the fundamental principles of plant nutrition and of plant physiology had accumulated through the work of such men as Liebig and Boussingault to lay the foundations for the beginnings of the real development of the water culture technique.

Liebig's[5] book, published in 1840, cleared the atmosphere of the many erroneous and misleading ideas of the time regarding not only the essential constituents of plants, but also the sources from which these constituents are derived. He was one of the first to correctly assign to the soil the rôle which it plays in the nutrition of plants, and recognized for the first time that the source of carbon in the plant is the carbon dioxide of the air. However, he denied oxygen respiration in the plant because of its connection with the elimination of carbon dioxide, nor did he understand the rôle of the soil as a source of nitrogen. The publication of his book on the application of organic chemistry to agriculture and plant physiology served as a great stimulus to the chemists and plant physiologists of the time toward undertaking the investigation of fundamental problems in plant nutrition.

Liebig's theory of the mineral nutrition of plants which attributed to the soil the function of supplying to the plant the mineral elements required for growth, as well as water, was experimentally verified by Boussingault[6] who grew plants in artificial soils consisting of inert, insoluble substances, such as quartz sand and charcoal which were watered with nutrient solutions of known chemical composition. By the use of these artificial solid substrates supplied with solutions of known composition, Boussingault was able to show that the minerals present in the ash of the plant were all derived from the soil and from the soil only. He further showed that plants were unable to make use of the uncombined nitrogen of the air, but were able to satisfactorily absorb their supply of this element from the solutions containing nitrates which he applied to his artificial soils in the complete absence of "humus," thus exploding also the outworn "humus theory" which postulated that the chief source of carbon and other essential materials for plant growth is the animal and plant wastes which accumulate in the soil. The honor of initiating the modern approach to the methods of investigating the inorganic nutrition of plants must be assigned to Boussingault, more than to any other, and in this approach water culture technique assumed a major rôle.

After it was once recognized, largely through the work of Liebig and Boussingault, that in the economy of the plant it is the chief function of the soil to provide the mineral elements required for growth and that these elements could

[4] C. Sprengel, "Die Lehre vom Dünger." Leipsig, 1839.

[5] Justus von Liebig, "Die organische Chemie in ihrer Anwendung auf Agrikultur und Physiologie." Braunschweig, 1840.

[6] Boussingault. "Recherches sur la vegetation." (A long series of papers, publication of which began about 1837 and continued until his death in 1887.) References in "Agronomie chimie agricole et physiologie," 3rd edition. Paris, 1886.

be added, in the form of solution, to an inert, insoluble substrate from which the plant could effectively absorb these elements, it was then only a step further to attempt to supply the necessary elements, as well as water, to the plant independently of any solid medium, even an artificial soil. With this idea finally well established through the work of Boussingault it may be regarded as having brought to a close the second period in the history of solution culture of plants after a time lapse of about sixty years.

The third period in the history of water cultures began about 1860. The real development of the water culture technique was initiated with this period. It was the natural outgrowth of the more modern ideas about the fundamental principles underlying the nutrition of plants. After it had been discovered that plants could be successfully grown in an artificial insoluble medium supplied with the mineral salts in the form of solution and that a "natural soil" was not an essential, the attempt to grow plants in a water solution of known composition followed as the next logical step.

During this period the investigation of the pressing problems in the nutrition of plants followed two general methods. One of these was to compound an artificial soil of insoluble, inert constituents and add to it solutions of soluble salts which were known to be essential for growth. This method, introduced by Boussingault, improved and extensively used by Salm-Horstmar[7] has since 1860 undergone many technical improvements and has been employed by many investigators for experimental work. The second method is that of "water culture" introduced and successfully used for the first time by Sachs to determine what are the essential mineral elements required for the growth of plants.

The water culture method, as it is known to-day, had its beginning at the time when Sachs[8] published the first standard formula for a nutrient solution for plants in 1860. The original technique developed by Sachs is still used extensively, practically unaltered. He believed the water culture method to be valuable for the investigation of fundamental problems in plant physiology because it eliminated many of the unknowns of the soil and provided a means of chemical control not attainable in the complex soil system.

The very extensive researches carried out during the early years of this period by Sachs,[9] Knop,[10] Wolf,[11] Nobbe,[12] Birner and Lucanus,[13] and others with the technique developed by Sachs proved to be very fruitful. The results of this work placed the water culture method and the preparation of culture solutions on a very definitely scientific basis and established the values and usefulness of the method in dealing with problems of the growth and metabolism of plants in general. During this period many standard solution formulas for the growth of plants in water culture were proposed and published. The use of solutions of known composition enabled the investigators to differentiate definitely between the essential elements required for growth and development and the non-essential elements which are absorbed by

[7] Salm-Horstmar, *Jour. Prakt. Chemie*, 52: 1–37, 1851; also 54: 129–133, 1851, and a series of papers published in the *Jour. Prakt. Chemie* from 1849 to 1855.

[8] J. Sachs, *Landw. Versuchsst.*, 2: 219–268, 1860.

[9] J. Sachs, *Landw. Versuchsst.*, 2: 22–31, 1860.

[10] W. Knop, *Landw. Versuchsst.*, 2: 65–99, 270–293, 1860, and a series of papers published between 1860 and 1865.

[11] W. Wolf, *Landw. Versuchsst.*, 6: 203–230, 1864, and 7: 193–218, 1865.

[12] F. Nobbe, *Landw. Versuchsst.*, 7: 68–73, 1865.

[13] H. Birner and B. Lucanus, *Landw. Versuchsst.*, 8: 128–177, 1866.

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the roots and appear in the ash of the plant. The elements required for green plants absorbed by the roots from the substrate were found to be potassium, calcium, magnesium, nitrogen, phosphorus, sulphur and iron. To these, as the result of later discoveries, must now be added manganese, boron, zinc, copper and perhaps some others. Another outstanding feature of the early investigations of this period was the observation by Knop, who concluded from the extent to which the several elements were absorbed by the plant from solution, that there was a greater resistance of the plant membranes to the penetration of sulphate than of nitrate. This observation suggested the concept of protoplasmic permeability as an important factor in the absorption of the various essential nutrient elements. The quantitative studies of Knop indicated clearly that the plant is able to absorb salts selectively under a wide variety of conditions. Even at this early period it was clearly recognized by the investigators that the composition of a culture solution could vary considerably without producing noticeable effects upon the plants provided only that the ranges in salt proportion were kept within certain limits and actual deficiencies of any of the required elements did not occur. Some of the nutrient solution formulas for the growth of plants which were proposed and published during the first decade of this period of solution culture history are still used extensively, notably that of Knop[14] published in 1865, which has perhaps been more widely employed than any other in studies dealing with the problems of plant nutrition.

The intense interest in water culture technique and its use in plant studies, which characterized the period between about 1860 and 1880 subsided emphatically during the last quarter of the nineteenth century and near the end of the century solution culture had practically fallen into the discard. Only a few researches of significance appeared sporadically in the literature during this time and the third period in the history of the water culture method came to an end with the close of the century. The progress which was made during these forty years had far reaching effects. It laid the foundations for more thorough study and a better understanding of the complex processes involved in the nutrition of plants. Furthermore, it had a profound influence upon the new science of plant physiology which marks its real beginning during the first years of this period. The investigations carried out during this period with the water culture technique have even to-day a tremendous influence upon fertilizer practices and soil management for purposes of large scale crop production.

The fourth and present period in the history of water culture and sand culture had its beginnings during the early years of the present century. It has been characterized by a vigorously renewed activity in the application of the water culture technique to solving the pressing problems of plant nutrition. This renewed activity followed immediately upon the discovery during the first decade of the century, of several new essential elements for plant growth. The fact that these newly discovered essential elements are required by the plants only in minute traces led to great improvements in the water culture technique, and great strides were made in the refinement of methods and in the purification of nutritive materials for accurate study. Better and more adequate equipment for the experimental set-up was devised and used. Through this great refinement of the water culture technique and improvement in the methods of operation

[14] W. Knop, *Landw. Versuchsst.*, 7: 93–107, 1865.

it is now possible to add to the list of essential elements for plants boron, manganese, zinc, copper and undoubtedly others will be added with still further chemical and physical refinements. A knowledge of the essential nature of these elements, although required by plants only in trace quantities, has already proven to be of definite practical importance in agricultural procedures for the commercial production of plants and plant materials.

During this present period many formulas for nutrient solutions have been proposed and published by Pfeffer[15] in 1900, by Crone[16] in 1902, by Tottingham[17] in 1914, by Shive[18] in 1915, by Livingston and Tottingham[19] in 1918, by Hoagland[20] in 1920, by Jones and Shive[21] in 1921 and others.

The newly aroused interest in the solution culture methods and the vigorously renewed activity in the experimental studies of plant nutrition during this period resulted in the development of new concepts relative to the processes involved in the absorption, assimilation and accumulation of the required elements by the plant from nutrient solutions. It led to the development of more accurate methods in following these processes in a quantitative way. As a result of this work it is now known that the elements are absorbed from solution in the ionic state and that the ions are selectively absorbed by the roots, and that this selective absorption profoundly influences not only the chemical composition and reaction of the nutrient medium but also changes some of the physical characteristics of the medium which in turn affect the activities and metabolic processes of the plant. A knowledge of the manner in which plants are capable of altering the physical and chemical properties of a culture solution suggested the desirability of renewing the nutrient supply at frequent intervals in order to overcome these disturbing influences in quantitative studies. This led to the development of various devices and mechanisms by which the culture solutions in either water cultures or sand cultures can be automatically renewed, without interruption, by continuous flow methods. Such devices have been used and described by Trelease and Livingston,[22] by Shive and Stahl,[23] by Johnston[24] and others, and they have played an important part in the development and effectiveness of the water culture technique.

It has been shown also through the work carried out during this period that plants can absorb from solution an excess of the nutrient elements beyond that required for maximum production if the elements are maintained in the medium in sufficiently high concentration. As the result of such studies considerable attention has been given to the concept of "physiological balance" of salt and ion proportions in culture solutions.

The intense interest and the remarkable activity not only in the development and use of the water culture technique

[15] W. Pfeffer, "The physiology of plants." Translated by A. J. Ewart, Oxford, 1900.

[16] G. Crone, "Ergebnisse von Untersuchungen über die Wirkung der Phosphorsäure auf die höhere Pflanzen und eine neue Nährlösung." Sitzungsber. Niederrhein. Gesel. Nat.-und Heilkundee Bonn. 1902: 167–173, 1902.

[17] W. E. Tottingham, *Physiol. Res.*, Vol. 1, No. 4, May, 1914.

[18] J. W. Shive, *Amer. Jour. Bot.*, 2: 157–160, 1915, and *Physiol. Res.*, Vol. 1, No. 7, Nov., 1915.

[19] B. E. Livingston and W. E. Tottingham, *Amer. Jour. Bot.*, 5: 337–346, 1918.

[20] D. R. Hoagland, *Science*, N. S., Vol. 52, No. 1354, pp. 562–564, Dec. 10, 1920.

[21] L. H. Jones and J. W. Shive, *Jour. Agr. Res.*, XXI: 701–728, 1921.

[22] S. F. Trelease and B. E. Livingston, *Science*, 55: 483–486, 1922.

[23] J. W. Shive and A. L. Stahl, *Bot. Gaz.*, Vol. 84, No. 3, Nov., 1927.

[24] E. S. Johnston, *Plant Physiol.*, Vol. 2, No. 2, 213–215, 1927.

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but in all phases of plant studies has resulted in a greater advancement of the science of plant physiology in general and in a better understanding of the fundamental principles of plant nutrition in particular during the past quarter of a century than has been accomplished during all the previous years. Yet many of the most important problems relating to the nutrition of plants still remain unsolved and the water culture technique and culture solutions must surely be employed in their solution. It is important to call attention to the fact that the water culture method in its present stage of development provides a research tool of incalculable value in the hands of the trained plant scientist. It is also interesting to note that this scientific tool has been developed through the years without any thought toward its ultimate practical application to the production of plants and plant products on a broad commercial and agricultural basis. Until quite recently it was employed exclusively in connection with laboratory investigations dealing with fundamental questions of plant nutrition and physiology in which a high degree of experimental control is an essential feature. The scientific interest which has developed in this subject, and the importance which it has assumed in recent years, is indicated by the interesting fact that at the beginning of the present period in its history, very few laboratories engaged in plant nutrition studies were making use of the water culture methods. At the present time, on the other hand, there are very few laboratories seriously engaged in the investigation of problems relating to the nutrition of plants, which do not employ and benefit by these methods.

During a decade or more attempts have been made to modify and to adapt the water culture technique of the laboratory for the production of plants on a commercial scale in the greenhouse and in some cases with a considerable degree of success. Among the early efforts in this direction is the work of Gericke[25] at the University of California, Biekart and Connors[26] at the New Jersey Agricultural Experiment Station, Withrow and Biebel[27] at the Indiana Agricultural Experiment Station of Purdue University, Eaton[28] of the U. S. Department of Agriculture, Riverside, California, and Hoagland and Arnon[29] at the California Agricultural Experiment Station.

For the commercial growth of plants with water cultures large shallow tanks are employed to hold the culture solutions. Over the tops of tanks are placed wire screens to hold a bed of litter in which the plants are supported over the solution with their roots protruding through the litter into the solution below. The porous nature of the bedding litter which supports the plants and the shallowness of the tanks is supposed to provide an aerating system but actually does not supply an adequate quantity of oxygen for the needs of the plants. This adaptation of the experimental laboratory method of water cultures to commercial growing of plants was suggested and described by Gericke.[25]

A system less troublesome to operate than the water culture technique is an adaptation of the laboratory sand culture method which was probably first suggested for the commercial production of plants by Robbins.[30] Water-tight

[25] W. F. Gericke, *Amer. Jour. Bot.*, 16: 862, 1929, and numerous articles since published.

[26] H. M. Biekart and C. H. Connors, *N. J. Agric. Exp. Sta. Bul.*, 588, 1935.

[27] R. B. Withrow and J. B. Biebel, *Jour. Agric. Res.*, 53: 693–701, 1936.

[28] F. M. Eaton, *Jour. Agric. Res.*, 53: 433–444, 1936.

[29] D. R. Hoagland and D. I. Arnon, Univ. of California Cir. 347, Dec., 1938.

[30] W. R. Robbins, *Proc. Amer. Soc. Hort. Science*, pp. 368–370, 1928.

greenhouse benches are filled with inert solid material, such as sand, gravel, crusted trap rock or sometimes cinders. There materials are periodically flooded with the culture solution, either from above or from below, by the so-called sub-irrigation system, which is then permitted to flow back into a solution reservoir through a drainage system previously installed. This method provides adequate support for the plants, as well as an effective aerating system. It is the method which is most generally employed for the commercial production of plants in greenhouses. All of these methods are adequately described in the literature and their operation fully explained and they need no further mention here.

Since in these methods of growing plants on a large scale the culture solution takes the place of the soil in supplying mineral nutrients and water to the plants, they have been described under various names, such as "dirtless farming," "tray agriculture," "tank farming" and "hydroponics." Through the extensive publicity given to this subject by the popular press during the past two or three years it has caught the attention of the general public and has taken a prominent place in the interest and imagination of plant growers and plant lovers throughout the world.

The popular accounts of the recent activities with these methods of growing plants, which appear frequently in the newspapers and popular journals of all sorts, have created the impression that a new system of "soilless farming" has been developed which bids fair to revolutionize present methods of crop production and is destined to displace classical agriculture. Wholly unfounded claims have been made by promoters and popular writers who are completely lacking in knowledge of the first principles underlying the growth and development of plants in general and of plant nutrition in particular. Advertising schemes of all sorts hold out these methods of "soilless growth" to the unwary amateur as an easy road to quick profits.

It can not be too strongly emphasized that this recently publicized and so-called "new method of soilless growth" is merely the application of approved laboratory experimental water culture and sand culture procedure to large-scale technique. It involves no newly discovered facts concerning plant requirements, but has been developed on the basis of an understanding of the underlying principles of plant nutrition gained through investigations over a long series of years conducted on a laboratory scale. It should be pointed out also that solution culture and sand culture methods, whether employed on a laboratory scale or for commercial production, contrary to the impression which casual acquaintance with this subject might convey, are far from being proof against failure. Successful plant growing, either on a small scale or on a large scale basis, in soil culture, water culture or sand culture, is an exacting art, demanding a knowledge of technique, plant requirements, and plant behavior. The use of solution or sand culture methods of growing plants in no manner removes the necessity of such skill and knowledge. These methods do offer certain advantages over soil methods, particularly in the matter of nutrient control. On the other hand, certain technical difficulties encountered with these methods do not arise when plants are grown in soil, because in a soil made fertile by simple treatment, many of the factors which determine the nutrition of the plant are automatically adjusted.

While there is sufficient experimental evidence to indicate that the production of plants on a commercial scale by the water culture and sand culture methods is possible there is no authentic evidence

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upon which to base the claims, all too frequently made, that yields produced by these methods are greatly superior in quality and quantity to those of plants grown in fertile soil under identical environmental conditions. On the other hand, it has recently been shown by Arnon and Hoagland[31] that yields produced by plants grown in culture solution on a comparative basis of season, time period, and experimental conditions, in both quality and quantity, were not greatly unlike the yields produced by plants grown in soil.

The history of the development of the water culture and sand culture methods and the experiences of the past eight or ten years in the attempts to apply this technique to the commercial production of plants and plant products makes it possible to predict that these methods can have no general agricultural significance in the near future, except perhaps in quite localized areas and under very special conditions. On the other hand, there is little doubt that in the near future this technique will play a major rôle in the commercial production of greenhouse crops. It is to be emphasized, however, that the water culture and sand culture techniques as they have been developed over the years are now, and must continue to be, a very important scientific tool for the experimental investigation of problems of plant nutrition, plant pathology, and other agricultural problems, and their application to large scale production is certain to promote their usefulness as an experimental tool.

[31] D. I. Arnon and D. R. Hoagland, *Science*, 89: 512–514, No. 2318, June 2, 1939.

THE CONTRIBUTIONS OF JOSIAH WILLARD GIBBS

TO-DAY the world is made clamorous by men who assert that they are strong and seem to be in a fair way of proving it. Just what place history will assign them remains to be seen, but there is no doubt as to their impact on our own time.

The world can well be reminded that history reserves some laurels for quiet people, and for peaceful achievement; the scholar has his place as well as the warrior. For those who in the non-political spirit of study release new knowledge, history reserves some of its best places. Such a one was Josiah Willard Gibbs, a graduate of Yale in the class of 1858 and professor of mathematical physics for over thirty years in the university. A complete example of the academic man, he was one of the great scientists of modern times, and one of the architects of the industry which is so important a part of our civilization. The one-hundredth anniversary of his birth will be observed in the present year. . . .

The first direct result of Gibbs's work was a great stimulus to physical science. He was the greatest single influence on the exact development of a new discipline—that of physical chemistry. He added greatly to knowledge concerning osmotic pressure and dilute solutions. He shaped our present concepts of chemical thermodynamics and electrochemical thermodynamics, and thus paved the way for an understanding of many metallurgical problems. The manner of this achievement was as remarkable as its content. Gibbs was not an experimenter, and there were few experiments to which he could turn. In building on the first two laws of thermodynamics he could go only where logic could take him, and the fact that he went so far is a tribute to a profound ability in mathematical reasoning. His work is marked by uncanny accuracy and simplicity and elegance of method. He never made mistakes, and everything that he did has survived all criticism. . . .

Gibbs fashioned a key to one set of natural forces; it is an accurate key, and its use is limited only by the occasions on which man wishes to investigate or control the forces coming under thermodynamic laws. With the great expansion in scientific activity, his formulae find uses over an ever-widening field of human endeavor. For example, many research programs in medicine are studies of the physical chemistry of the human body, and they bring into biological research the work of Gibbs. As industry depends more and more upon exact methods, the shadow of this quiet scholar falls more and more over the great establishments which are at the heart of our national economic life.—*From a Professor's Theory and its Practical Uses, Yale University.*

THE TRICHINOSIS SITUATION IN THE UNITED STATES

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DURING the last three years there has been considerable discussion in the popular and medical press on the subject of trichinosis. So far as can be ascertained from available information, the increased interest in trichinosis has not been stimulated by severe outbreaks of this disease, but rather by investigations which have uncovered infection with trichinae in human cadavers, these infections having been unaccompanied, apparently, during life by evident signs of illness. The facts brought to light by these investigations showed that a surprisingly large percentage of persons dying from various diseases in hospitals located, for the most part, in densely populated cities, contained trichinae in the muscles. The degree of infection discovered in the course of these investigations was on the whole very light, and was not considered by any of the investigators as the immediate or even a contributory cause of death. However, the discovery that in some cases 20 or more out of every 100 persons examined after death contained trichinae in the diaphragm produced considerable repercussion, and the subject of trichinosis is now being widely discussed in the public press.

HOW MAN ACQUIRES TRICHINAE

Human beings acquire an infection with trichinae solely as a result of eating the raw flesh of an animal that harbors these parasites. Animals become infected in the same manner. It is evident, therefore, that only carnivorous and omnivorous animals can transmit trichinae to man and to one another. Of the susceptible food animals that are slaughtered for human consumption in the United States, none are carnivorous and the hog alone has omnivorous habits. Pork is, therefore, the source of human trichinosis in this country. The only known exception to this general rule is the occasional transmission of trichinae to man by the consumption of bear meat.

PREVALENCE OF TRICHINAE IN SWINE

Although trichinae were first discovered in swine in the United States in 1846, no information was available as to the extent of infection with these parasites in hogs until some years after the establishment of the Federal Bureau of Animal Industry in 1884. Under the meat inspection act of March 3, 1891, provision was made for a microscopic examination of all pork intended for export, in order that certificates could be issued setting forth their freedom from trichinae. This act, the enforcement of which devolved upon the then 7-year old Bureau of Animal Industry, had the effect of lifting the restrictive measures against pork of American origin by the countries that had erected trade barriers against this commodity and incidentally supplied much needed information on the incidence of trichinae in swine in this country.

Out of 8,257,928 swine carcasses examined microscopically by federal inspectors between the years 1898 and 1906, approximately 1.5 per cent. were found to contain live trichinae and about 1 per cent. were found to contain what were regarded as dead or disinte-

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grating trichinae, or bodies that resembled trichinae, giving a total maximum infection discovered by the microscope of about 2.5 per cent.

Following the abandonment of microscopic inspection for trichinae of pork intended for export, after the passage by Congress in 1906 of the new meat inspection act, the prevalence of trichinae in hogs in this country became largely a subject of speculation for nearly three decades. The figures commonly quoted in various articles on trichinosis were those that had been brought to light by Government microscopists up to 1906.

With the reawakened interest in human trichinosis stimulated, as already stated, by surveys on the occurrence of trichinae in human cadavers, the Federal Bureau of Animal Industry initiated in 1933 a survey to determine the status of trichina infection in hogs and to trace, if possible, this parasitic infection to its source. In planning this survey, the writer decided to use an improved method of examination, consisting in the digestion of the entire diaphragm of each hog involved in an artificial digestive fluid containing pepsin and hydrochloric acid.

It had been recognized for a long time that microscopic inspection of pork for trichinae is at best a hit and miss method, and that light infections could be discovered by this procedure only occasionally, since the quantity of meat that could be compressed sufficiently thin between glass slides to make the field visible through the microscope is necessarily very small. By the digestion technique, which is applicable to research only, a considerable quantity of meat can be examined, the results giving rather reliable information on the presence or absence of trichinae. When present, the trichinae are freed from the meat in the course of digestion and sink to the bottom of the vessel in which digestion is taking place. The parasites, whether dead or alive, are easily discovered by direct microscopic examination of the particles which settle in the digestive fluid.

By this procedure, there were examined between the years 1933 and 1938 approximately 25,000 diaphragms from as many hogs originating in the most important swine-breeding centers of this country. Of the samples so examined, 13,000 were obtained from swine that had been raised on farms and fed forage, grain and other feeds, including, in some cases, more or less garbage, and about 10,500 were obtained from swine determined to have been fed, as the main or a large portion of their diet, garbage as collected from municipalities and institutions. Leaving out of consideration the remaining samples obtained from hogs known to have been fed cooked garbage and which, as a consequence of this diet, had practically negligible infections with trichinae, the findings in the two groups of hogs under consideration were as follows:

Only 126 out of the 13,000 diaphragms from as many farm-raised hogs contained trichinae, whereas 599 out of the 10,500 diaphragms from as many garbage-fed hogs contained these parasites. Some lots of garbage-fed as well as farm-raised hogs were free from trichinae. The average incidence of infection in the farm-raised hogs was 0.95 per cent. and that in the garbage-fed hogs 5.7 per cent. In other words, the average incidence of infection with trichinae in garbage-fed hogs was six times as great as that in hogs raised on the farm. In both groups of hogs the degree of infection was very light in the vast majority of cases. In fact, between 70 and 80 per cent. of the trichina-infected hogs in the two groups had infections of a kind characterized by the presence of less than one larva per gram of diaphragm muscle tissue. Since the

diaphragm is known to be one of the preferred locations of these parasites, it is safe to conclude that the degree of infection in the positive carcasses as a whole was much lighter than that in the diaphragms.

It is obvious that in order to arrive at the present-day incidence of trichinae in swine in the United States it would be unfair to average the incidence findings in farm-raised and garbage-fed hogs, for the reason that the latter represent only a small part of the total number of hogs that come to slaughter. Precise information on the percentage of garbage-fed hogs that are marketed annually in the United States is unavailable. However, assuming that 10 per cent. of these hogs are garbage-fed, and some authorities on animal industry would regard this figure as being too high, the present-day average incidence of trichinae in all swine, based on the incidence findings discovered in our survey, would be approximately 1.5 per cent.

On superficial comparison, the incidence figure based on the newer findings is precisely that discovered by Bureau of Animal Industry microscopists between the years 1898 and 1906, during which period 1.5 per cent. out of more than 8,000,000 hogs examined microscopically were found to contain live trichinae. It must be borne in mind, however, that the incidence as determined by microscopic examination in previous years can not be compared to that determined by the digestion technique employed in our recent investigations. In order to arrive at a scientific basis of comparing the new incidence figure with that determined in previous years, samples from approximately 50 per cent. of the trichina-infected hogs, as discovered by the digestion technique, were also examined microscopically, three samples being examined from each diaphragm with the aid of compressor slides. Only 21 per cent. of the known positives, in the order in which they were detected by digestion, were found to show trichinae by microscopic examination. This is not surprising, considering the fact that between 70 and 80 per cent. of trichina-positive hogs in our series had exceedingly light infections, as previously mentioned. It would follow, therefore, that routine microscopic examination reveals trichinae only in carcasses that are moderately or heavily infected and fails to detect practically all of the light infections.

Assuming that the findings with reference to the incidence of trichinae in hogs discoverable by the two methods herein reported are generally valid, the incidence of trichinae in hogs discovered by Bureau of Animal Industry microscopists represented only about one-fifth of the real incidence. In other words, the incidence of infection with live trichinae in hogs during the previous period mentioned, was actually about 7.5 per cent. as compared to the present-day incidence of 1.5 per cent. This shows a sharp decline in the extent of trichina infection in swine during the past three and one-half decades and augurs well for a continued decline due to increasing progress in sanitary methods of swine production.

Control of Trichina Infection in Swine

While there is considerable comfort in the knowledge that there has been a decided decline in the extent of trichina infection in swine over a period of nearly 35 years, those concerned with the live-stock and meat industries must take cognizance of the fact that the present-day status of trichina infection in hogs still leaves much to be desired. The present incidence of trichina infection presents a challenge to live-stock sanitarians, swine breeders and the

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meat industry of this country, and indicates that much effort must be exerted to reduce the extent of and perhaps ultimately eliminate altogether this parasitic infection in swine. With the diminution of trichina infection in swine there will be, undoubtedly, a corresponding decrease of clinical trichinosis as well as non-clinical trichina infection in human beings.

The evidence presented in this paper shows that the feeding to swine of garbage as collected favors the spread of trichina infection among these food animals. Since hogs can acquire trichinae only as a result of eating raw, trichina-infested meat, it is obvious that such meat must be present from time to time in the feed. When garbage is a large or a major part, or the sole feed of hogs, these animals have a greater opportunity of acquiring trichinae than when garbage is fed to them only occasionally. The fact that nearly 1 per cent. of 13,000 farm-raised hogs were found to contain trichinae is conclusive evidence that these host animals must have had access at some time or other to scraps of raw meat, presumably pork, contained in home or other garbage that was intentionally fed or made available to them.

The role of rats in the transmission of trichinae to swine is still a somewhat debatable point. However, the exceedingly low incidence and low intensity of infection with trichinae in swine fed cooked garbage, as determined in the course of our investigations, would tend to relegate the rat to a comparatively unimportant role in the transmission of trichinae to swine.

Assuming, therefore, that raw pork scraps in garbage constitute the main source of trichinae for swine, the elimination of these parasites from hogs necessarily involves the elimination of uncooked meat and bones from garbage. In cases in which this is not feasible, the feeding of garbage as collected must be eliminated altogether in order to control swine trichinosis. These recommendations apply to farm-raised as well as garbage-fed hogs, because the evidence obtained in the course of our investigations, as already stated, shows that 1 per cent. of hogs raised on farms harbor trichinae. The elimination of commercial garbage feeding only would still leave a large residuum of infection with trichinae in farm-raised hogs. The extent of what this residuum of infection would be is shown by the following considerations:

During the year ended June 30, 1939, there were slaughtered under federal inspection approximately 38,500,000 hogs. On the assumption that 10 per cent. of these animals were garbage-fed and that 5.7 per cent. of these garbage-fed hogs harbored trichinae, nearly 220,000 of these hogs were probably infected with the parasites under consideration. Among the remaining 90 per cent. of the hogs slaughtered under federal inspection, about 345,000 probably contained trichinae, assuming roughly a 1 per cent. incidence of infection in these host animals. It is evident, therefore, that the elimination of commercial garbage feeding would reduce the number of trichina-infected hogs only by approximately 40 per cent. and would still permit the remaining 60 per cent. of trichina-infected carcasses to be sold as fresh pork. The effective control of trichinae in swine must involve, therefore, due attention to the feeding of hogs raised on the farm as well as garbage-fed hogs (in order to eliminate from the feed of these animals scraps of raw pork, bones, offal, dead rats) and to the proper disposal by cremation or deep burial in quicklime of all hogs and other animals that die on the farm.

Prevention of Human Trichinosis Through Federal Meat Inspection

The reduction to negligible proportions and the ultimate eradication of trichinae from swine represent sound goals in livestock sanitation. However, since ideal goals in various spheres of human endeavor are seldom attained, much good can still be accomplished by making a compromise between the ideal and the practical. Considering the difficulties involved in the eradication of trichinae from swine, much can be done and much has been done already to reduce the incidence of the disease, trichinosis, in man by certain meat inspection procedures.

It is unfortunate that nature made trichinae so small that their presence in a hog carcass can not be discovered by the naked eye. Encysted trichinae in the muscles are spirally rolled, the individual worms being enclosed in connective tissue cysts, approximately one fiftieth of an inch in diameter. Since the cysts and inclosed parasites do not stand out in sharp contrast to the meat, except in infestations of long standing, trichina-infected pork does not differ in appearance and texture from non-infected pork. In the course of routine inspection of hogs, trichina-infected carcasses, therefore, escape detection.

In the regulations governing the meat inspection of the U. S. Department of Agriculture, there is contained the following provision:

> Inasmuch as it cannot certainly be determined by any present-known method of inspection whether the muscle tissue of pork contains trichinae, and inasmuch as live trichinae are dangerous to health, no article of a kind prepared customarily to be eaten without cooking shall contain any muscle tissue of pork unless the pork has been subjected to a temperature sufficient to destroy all live trichinae or other treatment prescribed by the chief of bureau.

The treatments prescribed by the Chief of the Federal Bureau of Animal Industry for all meat food products containing pork muscle tissue that are prepared to be eaten customarily without cooking, are (1) heating, (2) special refrigeration and (3) special processing, these procedures having been found by extensive, painstaking scientific investigations to be adverse to the life of trichinae. Under the prescribed heating it is required that all meat food products of kinds mentioned must be so heated that they will attain in all parts a temperature of not less than 137° F. The required refrigeration involves the subjection of pork or of articles containing pork muscle tissue to a temperature of not higher than 5° F. for a continuous period of not less than twenty days, provided the meat or articles, not exceeding six inches in diameter, are hung up singly or packed in boxes not exceeding six inches in thickness. In the case of pork or products packed in barrels or tierces, the period of refrigeration is extended to thirty days.

Owing to more or less recent improvements in refrigeration, it has been determined that meat packing establishments operating under federal inspection commonly maintain their freezers used for treating pork to destroy the vitality of trichinae at temperatures much lower than 5° F. With this in mind, investigations were conducted recently by the Bureau of Animal Industry to determine the extent to which the required holding period of pork and products could be decreased if the temperature of the freezer is maintained at −10° F. The results of these investigations showed that when pork is packed in boxes not exceeding six inches in thickness, the required holding period in freezers maintained at −10° F. could be reduced to ten days and that when the meat or products are packed in tierces, the period of refrigeration need not be extended beyond twenty days. Tests

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were made also with trichinous pork kept in freezers maintained at a temperature of –20° F. As would naturally be expected, it was determined that the required holding period at this low temperature for pork packed in boxes not exceeding 6 inches in thickness could be still further reduced, actually to six days; and for pork packed in tierces, the period could be reduced to twelve days. These results show, therefore, continued progress in investigations of and ultimate application of practical methods designed to destroy the vitality of trichinae in pork destined to be converted into products of kinds customarily eaten by the consumer without cooking.

Special curing methods prescribed by the chief of the Bureau of Animal Industry, in lieu of the required refrigeration or heating, involve the destruction of the vitality of trichinae by salt, at specified temperatures for definite periods. These curing methods, which are based on empirical formulae, were tested in the course of a series of extensive investigations and found to be effective in destroying the vitality of trichinae before their use was permitted in officially inspected establishments.

During a recent period of five years there were examined in the laboratories of the Zoological Division of the Bureau of Animal Industry over 10,000 one-half pound samples of meat food products originating in federally inspected establishments and designed to be eaten by the consumer without cooking. Each sample was examined by the method of digestion previously mentioned, and in no instance did any of these products contain trichinae capable of developing in human beings or in other susceptible animals. On the other hand, in the examination of 1,000 samples from products not processed under government requirements for the destruction of trichinae, 45 were found to contain live trichinae. These results show conclusively that processing for the destruction of trichinae, as enforced by federal meat inspection, is an effective safeguard against human trichinosis.

Possibility of Controlling Trichinosis in Man by the Skin Testing of Swine

About a dozen years ago the writer began experimenting with the skin test as a possible method of diagnosing trichinosis in live hogs. Since that time this subject has been under investigation in our laboratories, and during the past two years it has been one of our major research projects. The results of over 5,000 such tests made by Spindler and Cross, parasitologists of the Bureau of Animal Industry, were published some time ago. Six thousand additional tests made by these workers, the results of which are as yet unpublished, confirmed their earlier work and showed that, in the main, the extracts of trichinae to be injected into hogs (antigens) prepared by methods that were employed commonly in the past for the diagnosis of trichinosis in man can not be depended upon to give reliable results when used in hogs that come to slaughter.

Recently Lichterman and Kleeman, of the Board of Health of New York City, proposed a skin test for the detection of trichina infection in hogs, the results of which, according to these investigators, were nearly perfect. By following the technique employed by these investigators, tests carried out in our laboratories gave disappointing results. Only seven out of twenty trichina-infected hogs gave clear-cut skin reactions, four gave doubtful reactions and nine gave negative reactions. Out of 257 uninfected hogs, 106 gave clear-cut reactions, seven gave doubtful reactions and 144 gave negative reactions.

Continued work on the skin test is

progressing in our laboratory with encouraging results from time to time. Whether a skin test can be ultimately devised that will combine a high degree of specificity in detecting all, or nearly all, infected hogs and giving no reaction in all, or nearly all, non-infected hogs, can be determined only by additional investigations which must take into consideration, among other things, rapidity of the application and noting the results of the test, in keeping with the swift pace of hog killing which prevails in practically all establishments operating under federal inspection.

It must not be overlooked that an effective skin test, if developed and found to be practical, would apply only to hogs slaughtered under federal and other equally rigid inspection. Approximately one third of the hogs in this country are not slaughtered under such inspection; these would not, under present requirements, be subject to the test. Trichina-infected, fresh pork from this non-supervised slaughter would still be entering the channels of trade, unless the skin test were universally adopted. Considering the fact that but few States and not a great many municipalities enforce a rigid meat inspection, it is doubtful that a skin test for the detection of trichinae would be adopted in connection with all slaughter of hogs.

Summary and Recommendations

Considering the fact that approximately 1.5 per cent. of hogs which come to slaughter are infected with trichinae in varying numbers, it is essential that fresh pork and pork-containing meat food products of kinds not processed for the destruction of the vitality of trichinae, be cooked thoroughly in the home and public eating places. Meat-food products containing pork muscle tissue of kinds prepared to be eaten without further cooking are safe, provided they were prepared under Federal or equally competent inspection. Processors not operating under inspection would do well to adopt voluntarily the processing procedures developed by the Federal Bureau of Animal Industry for the destruction of trichinae. This should be done in the interest of human health as well as a protection from lawsuits growing out of trichinosis in human beings alleged to have resulted from the consumption of products sold as fit for consumption without subsequent cooking.

The elimination of meat scraps from garbage of all kinds, including that on the farm, or the elimination of feeding to hogs of garbage as collected, unless the latter is definitely known not to contain raw meat, will reduce sharply the extent of trichina infection in hogs. The prohibition of the feeding of garbage to hogs on a commercial scale alone will eliminate only approximately 40 per cent. of the trichinous hogs, assuming that this prohibition could be meticulously enforced.

Although the available evidence indicates a sharp decline in the extent of trichina infection in hogs during the past 35 years, livestock sanitarians, swine producers and meat packers must not relax their efforts in bringing about a continued reduction, even at a greater pace than heretofore, in the incidence of these parasites in swine. Such efforts, if carried out successfully, will eliminate from pork the stigma which now sometimes attaches to it, as being responsible for the production in man of the disease trichinosis, and non-clinical infection with trichinae.

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THE RESPONSIBILITY OF EDUCATION TO SOCIETY

By Dr. HARRY ELMER BARNES

COOPERSTOWN, NEW YORK

I

THE attitude of man toward the responsibility of education to society has altered markedly, in keeping with the progress of human knowledge and culture. In primitive and oriental society education was informal and consisted chiefly in conserving the culture of the past and transmitting the customs and the traditions of the community. Education was, thus, a religious as well as a social duty. There was little comprehension of the idea that man should pass on the cultural tradition for the purpose of improving human society. It was taken for granted that the social order was the work of the gods and, hence, was as perfect as it could well be. Indeed, the very idea of altering or criticizing the accepted social tradition would have been an act of impiety. It was firmly believed that the best, indeed the only, way of insuring prosperity and security was to retain the existing social order unchanged and unquestioned.

The Greeks were the first to challenge this attitude. The Ionic philosophers were the earliest human thinkers to reject the traditional account of things and to bring the resources of the human mind to bear upon the analysis of traditional interpretations of nature and social institutions. The later Greek philosophers not only extended this critical function of human thought, but thoroughly comprehended the fact that education might be made a fundamental instrument of social reform and a major agency in promoting human progress. Indeed, in his "Republic," Plato proposed that the control of society should be placed in the hands of educators and philosophers. But such revolutionary ideas as these were restricted mainly to the philosophical students of education. The formal education of classical times, except among the few advanced students of philosophy and science, was still devoted mainly to transmitting and re-enforcing the mores, institutions and ideas of earlier generations. The central element in respectable classical education, namely, rhetoric, was well designed to promote intellectual conservatism and docility.

In the Middle Ages, education was primarily given over to inculcating both divine truths and social tradition. It employed rhetoric, logic and theology to create a well-rounded and coherent body of knowledge designed to give finality to the approved social structure. In practice, it trained youth to participate dutifully and efficiently in feudal society or in the bureaucracy of the church and the state.

Neither Humanism nor Protestantism wrought any fundamental revolution in the social attitudes underlying education. While they may have contributed to the criticism of Catholicism and certain institutions which the latter controlled or favored, both Humanism and Protestantism were primarily interested in the transmission of antique tradition —one in a literary tradition and the other in a theological heritage. Both placed a new emphasis upon the individual, but neither made any important contributions to the idea of the responsibility of education for the reconstruction of society.

With the coming of the period of enlightenment we encounter a revival of the Greek idea that education may pro-

mote human happiness and well-being, both through training the individual and by reconstructing society. The eighteenth-century "perfectionists" were the first important modern champions of education as an instrument of social progress. They believed that education should be universal and that it would wipe out individual inequalities and antiquated obstacles to human happiness.

These educational doctrines were warmly espoused by James Gordon Carter, Horace Mann, Henry Barnard and other American apostles of education as an instrument for the promotion of democracy. They labored mightily to bring about free public education. But altogether too little attention was given to the content of the education which, it was hoped, would extend and perpetuate the democratic experiment. For the most part, the democratization of education consisted mainly in passing on the older heritage to a larger group. Though we have seen to it that everybody can now go to school, we have been far less wise and proficient in making it certain that what our children study in the schools is of direct relevance to the solution of our public problems. Since the days of Horace Mann, we have assumed to be interested in educating the common man for the duties of citizenship in the contemporary world. Yet, in spite of the highly novel character of our civilization, the basic content of reputable education still remains roughly similar to that which was deemed suitable for the instruction of the children of the European nobility three centuries ago. Indeed, one of the most widely discussed of the recent plans for revamping our present system of education proposes to revive the educational attitudes and curriculum which were utilized to train prospective priests in the thirteenth century.

The educational innovators of the period of the enlightenment, such as Rousseau, were interested in the responsibility of education for both the personal development of the child and the reconstruction of the social order. But even our most progressive professional students of pedagogy have remained chiefly absorbed with educational responsibility for the individual, ignoring the fact that no individual can secure proper development in a cramped and restricted social environment. Education helped to strike off the chains of punitive discipline, but it gave little heed to the equally paralyzing fetters of an oppressive and inequitable social order. Social philosophers, such as Henri Saint-Simon, Auguste Comte and Lester F. Ward, vigorously emphasized the need for social planning and the vital relation of organized education thereunto. But our pedagogues gave little heed to their teachings and exhortations. Even in our own day, when certain educators with a sociological perspective are shocking many by their supposed radicalism and daring, we find that they are doing little more than setting before us the sociological doctrines which were the common property of social philosophers more than a half century ago.

II

The failure of education to become alert to its responsibility for bringing about constant readjustments in the structure of society and in our social thinking has helped to create the outstanding social crisis of our generation, namely, the tremendous and ever-widening gulf between our mechanical equipment, on the one hand, and our social ideas and institutions on the other. Scientific and technical education have made it possible for us to create our impressive and efficient empire of machines. But our hesitation and timidity in using education as an instrument for social planning have enabled our machines rapidly to outdistance the social procession. We stand, to-day, with our mechanical foot in an airplane and our social foot

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on an ox-cart. Or, to use another figure, if we symbolize our technology by a turbine, our social ideas and institutions may be fairly compared to a windmill. The latter is, perhaps, most literally symbolic of our political life and institutions. Whatever immediate social problem we may consider, be it an economic, political or educational question, we are bound to find, upon closer examination, that it is only a secondary and subordinate manifestation of the major problem of our age, namely, the abyss which separates our machinery from our institutions.

The gulf between our material culture and our institutional life imposes upon mankind the most critical responsibility in the whole history of the race. If we bridge this gulf, by bringing our social thinking and institutions up-to-date, we can not evade the speedy realization of a material utopia. On the other hand, if we fail to do this we are likely to drift into economic collapse, world war, barbarism and chaos, including, perhaps, the extinction of a large portion of the race itself.

Mankind has never before been faced with a direct and immediate choice between utopia and catastrophe, but such are precisely the alternatives which are offered to western civilization to-day. If we overhaul our economic system, put our unparalleled mechanical equipment at the service of mankind and wipe out the menace of war, we can, within a decade or two, step into a condition which will make any of the utopias from Plato to Robert Owen seem drab, trivial and uninviting. We could quickly realize Edward Bellamy's dream, as expressed in "Looking Backward." This assertion does not even imply that we must wait for future mechanical marvels. The essential technology and natural resources are already at hand. In the United States we could provide a far higher standard of living than has ever been known, and could make it available to the masses with much less than thirty hours of work each week. There could be plenty, security and an abundance of leisure, which would enable us to attain the vistas of a "super-pig" culture that were envisaged by Plato in his "Republic."

This is one side of the picture. If we do not rise to our opportunities and make the most of our unprecedented mechanical equipment, then the whole economic machine is bound to break down within a few years. It has already broken down so badly in several countries as to necessitate a well-nigh complete cessation of civilized traditions and practices, in order to save it from complete collapse. In the largest country in the world, capitalism, as we know it, has already disappeared.

If we continue on the road of evasion—and of decline—we must face the prospect of collapse through internal weaknesses. The best we could then hope for would be insecurity, lower standards of living, greater unemployment, unrelieved want, misery and sheer starvation. To this must be added the ever-increasing danger of devastating warfare and a return to barbarism, for warfare to-day means wholesale destruction of physical equipment and civilized amenities.

We have created a machine age uniquely prepared to serve us or to wreck us. The outcome will depend upon the type of social control which we impose upon our empire of machines.

To close in the gap between our machines and institutions is, therefore, the supreme educational task and responsibility of our generation. It is absolutely mandatory, if we hope to preserve any modicum of real civilization. This suggests the question of why we are not taking seriously this outstanding challenge of our age.

In the first place, we are restrained because of the sharply contrasting attitudes which we entertain with respect to material and mental antiquities. We demand the most up-to-date models of auto-

mobiles, radios, bathtubs, electric light fixtures and all other gadgets. The average man would be inexpressibly embarrassed if he were compelled to drive along a public thoroughfare in a 1920 motorcar, even though the vehicle were in perfect condition. Yet this same man will inevitably cherish many ideas and support many institutions older than the stagecoach. Many a plutocrat who demands the very latest super-motorcar, unreservedly and unthinkingly venerates our Constitution, model 1787. Indeed, the only place where we of the human race esteem antiques more highly than in our living-rooms, is under our hats. So long as this state of mind exists, there is little hope of closing the gap between material culture and human institutions. Indeed, we feel that there are plenty of good reasons why we should not do so. Nevertheless, until we recoil from out-of-date institutions and ideas as spontaneously as we do from an old-fashioned vehicle or gadget, there is little hope of taking even the first steps which are required to preserve and pass on the civilization which our forefathers established.

Another obstacle to bridging the gulf between machines and institutions is to be found in our attitude toward expert guidance. When a man desires to have a bathroom faucet repaired, a spark plug replaced or a tooth pulled, he deems it necessary to have immediate recourse to an authentic expert. Yet, in the much more difficult problems of social, economic and political life, he will rest completely satisfied with the uninformed dogmas of the man on the street. He demands a brain trust to design his automobile, but rejects the suggestion that he may need one to plan his society or run his government. If he needs an operation performed on his body he seeks the best available surgeon, but he willingly permits the body politic to be ruthlessly mangled by ignorant and corrupt political butchers.

Far from bridging the gulf between material culture and social institutions, we are actually widening this menacing abyss. We offer almost every imaginable incentive to improve and extend our material equipment. Scientific prizes, patent royalties, industrial profits, social prestige and other enticing rewards are offered to those persons who provide us with more efficient machines and more convenient gadgets. At the same time, we place almost every conceivable obstacle in the way of those who seek to improve our antiquated institutional set-up.

There are no prizes for the social inventor. On the contrary, his suggestions are not even given tolerant consideration. Right in a liberal country like the United States, the best that a social inventor can expect is patronizing ridicule. He is more likely to be derided as a crank or made a social outcast. In other countries, less tolerant than we, the firing squad or concentration camp is his usual reward. At the very moment when we need, more desperately than ever before, intelligent proposals as to social reconstruction, we reject them with ferocity and even create Congressional committees to excoriate their authors.

III

In this task of bridging the gulf between machinery and institutions we come immediately to the outstanding responsibility of education to society in our era. The public problems of our day have become so complex and baffling that only organized intelligence, which should be another name for education, can hope to cope with this problem of modernizing our institutions. Good intentions and charitable impulses are no longer adequate to guide us amidst the mazes of contemporary society. We can hope to modernize our social ideas and institutions only by an enormous extension and improvement of the social studies, as the central item in our educational offerings.

In short, the responsibility of educa-

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tion to society boils down to three major phases of educational activity: (1) a highly discriminating conservation of the social heritage; (2) thoroughgoing and fearless social criticism; and (3) resolute and informed social planning.

It is as important as ever that education should pay attention to transmitting the heritage of the past. Without this knowledge, especially the knowledge required to operate our present technology and social system, man would be far more helpless than he would have been in primitive society without the support of the wisdom of the elders. But there is no longer any reason why we should uncritically accept the total social heritage. Indeed, we can not safely do so. Our past tendency to do this has created the social crisis of our day. We must view the heritage of the past from the vantage point of current knowledge. We must sift the social heritage through informed analytical examination. We must eliminate from serious consideration those obstructive antiques which are holding us back from bridging the gulf between technology and institutions. We are, to-day, equipped to discriminate between those aspects of the social heritage which have been tested and found valid through social experience, and those which are, obviously and flagrantly, the product of past ignorance, superstition and dogma. Further, we must create a critical attitude toward the heritage from the past, which will free the mind of the educated man from both reverent gullibility and cynical contempt.

In sifting the social heritage and in the creation of a mental attitude favorable to this process, historical studies can make the most direct and potent contribution. Indeed, this is probably the only important practical contribution which the study of history can make to education as an instrument of social progress. But this potential contribution of history is important indeed. We can not take even the first step toward bridging the cultural gulf and preserving civilization until we are able to assume a critical and analytical attitude toward our social thinking and institutions. This possible service of historical insight to social betterment constituted the main contribution of James Harvey Robinson to both historical study and the science of education. It may some day be regarded as one of the outstanding contributions of the twentieth century to constructive educational doctrine. Certainly, nothing is more urgently needed than the capacity to face the past with discriminating appreciation, free alike from both reverence and cynical indifference. No other study, save history, assumes any direct responsibility for bringing about such a result.

This creation of an intelligent attitude toward the past is indispensable as the preparation for the second major function of education, viewed as an instrument of social progress, namely, a critical appraisal of the existing social order. We can not even approach the present structure of society with any degree of objectivity unless we can view its origins with tolerant understanding. Likewise, we can not even be interested in working for a better social future until we are clearly aware of the weaknesses and inadequacies of the social order in which we live. It is for this reason that social criticism constitutes an extremely important item in the responsibility of education to society.

In the same way that history can best serve us by encouraging a discriminating appraisal of the past, so the other social studies must supply us with the means of critically assessing the social structures of our own time. This task of resolute social criticism constitutes an important phase of the descriptive work of the social studies. The first responsibility of the latter is to describe, realistically and completely, every aspect of the society in which we move. If this job is well done, the critical function of the social studies will emerge naturally and in-

evitably. Any competent description of, say, our social, economic and political institutions, will inevitably reveal their weaknesses and failures as well as their strength and success. Social criticism is, obviously, not the sole task or responsibility of the social studies, but it is certainly an indispensable phase of their contribution to the educational process. Until we are made completely aware of the defects of the existing social order we can have neither any incentive to work for a better social future nor any precise conception of what is actually required to bring about a better day.

The most immediate responsibility of education to society, right now, is therefore, the preparation of a blueprint of a better social system and a realistic indication of how we may bring this into existence in a gradual, peaceful and intelligent fashion. This is not merely a theoretical responsibility of education. It is a highly immediate and practical social necessity. We have already made it clear that human society is rapidly approaching the parting of the ways which lead to utopia or to chaos. The guidance of society by realistic education appears to many to be the only guarantee that we could choose the road to utopia. Certainly, it provides the only reasonable hope that this choice can be made without violence and destruction. Education has a very definite self-interest in this matter, on its own account. Unless we avoid economic collapse, social chaos, dictatorship and war, organized education can not be maintained in a state of dignity, independence and social prestige. Education must save democratic civilization if it is to save itself.

That this responsibility of education for reconstructing the social order is a very real and immediate one is readily apparent the moment we examine current world conditions. Many of the most essential aspects of American civilization, such as representative government, democracy, civil liberties, individualistic capitalism and private business enterprise have already disappeared or been thoroughly undermined in about two thirds of Europe. They are non-existent, or threatened, in most of the remainder of the Old World and in a considerable portion of Latin America. In the United States, we are paying around $5,000,000,000 a year in emergency expenditures simply to keep the capitalistic craft afloat, without any serious thought of weighing anchors and moving to more hospitable ports. And there seems to be every prospect that we shall have to pay more in the future, and get even less evident social advantages therefrom. As was painfully evident in 1937, even a slight letting up in salvaging expenditures caused the old boat to list dangerously and threaten to sink. In those countries where education failed to assume its social responsibility while there was yet time, education has been subordinated to propaganda and dogma, its independence and dignity shorn away and its curtailed personnel reduced to servility by intimidation.

If American educators evade their responsibilities in like manner, it is hardly to be expected that they will be preserved from a similar fate. There is no reason to believe that a totalitarian dictatorship can not easily be set up here, provided social conditions become ripe for one. And there are numerous and powerful elements in American society to-day who seem determined to create those social conditions out of which dictatorship and totalitarianism naturally and inevitably spring. And these elements are the very ones who are now most vociferous in detecting dictatorial symptoms in the New Deal.

It may be well to emphasize the fact right here that when I refer to "a better social order for the future" I am not remotely implying that we should imitate Soviet Russia or even create a moderate socialist régime. I have in mind only the very minimum reforms which

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might, possibly, make American democracy and capitalism workable for at least a generation. In order to avoid the charge of dealing only in vague generalities, I will briefly summarize what I conceive to be some of the more essential reforms of this character.

To make democracy workable we will have to introduce a number of sweeping changes. Some type of weighted or selective suffrage system will be required, wherein the vote of an able and well-educated person will count for considerably more than that of an illiterate moron. We must greatly extend the civil service system, so as to cover candidates for every type of office, executive, legislative and judicial. No man should be allowed even to be a candidate for any important office unless he can formally qualify for the responsibilities of the post in question. Our present archaic system of representation by territorial districts must be supplanted or supplemented by vocational and proportional representation. This would introduce realism and democracy into our system of representative government. The power of the Supreme Court to set aside federal legislation must be greatly curtailed, if not entirely eliminated. A system of responsible cabinet government, roughly similar to that of Great Britain, must be introduced. There is not the slightest chance that we will be able to survive as a democratic nation if we attempt any longer to operate a government based upon the absurd separation of our governmental structure into three independent and balanced departments—a political monstrosity taken over by the inexperienced fathers of 1787 from a misinterpretation of the British government by an ill-informed French publicist, who wrote a generation before the American Revolution.

To give capitalism the slightest prospect of survival and efficiency we would have to bring about reforms even more sweeping and drastic than we have suggested with respect to democracy. Our system of banking and credit will need to be as thoroughly nationalized as our monetary system is to-day. Holding companies, "the machine guns of the corporate racketeers," will need to be speedily legislated out of existence. The scandalous waste of our natural resources must come to an end, and a vigorous program of replacement and rehabilitation adopted. The sabotaging of potential production and technological efficiency by such policies as the rejection of new inventions, limitation of output, monopolistic restrictions and the like, must cease. And the price structure must be overhauled to conform with the opportunities afforded by the mass-purchasing power of our citizens. State capitalism will need to be greatly extended, so as to include the federal ownership and operation of railroads, electric utilities, coal mines and, perhaps, the heavy industries. Legislation will have to be provided to insure much higher minimum wages and a much more adequate scheme for the spreading of work. We must look forward to a far greater range and volume of public works, even in normal times, with much more elaborate plans drawn up and held in readiness for those moments of emergency created by depressions. Collective bargaining must be legalized in fact as well as in letter. Finally, there must be a marked development of cooperative economic enterprise to supplement both state and private capitalism.

We must have a type of farm legislation which will insure sufficient income for the farmers without placing a premium upon non-production. In other words, we must insure enough profitable farm production to provide everybody with a liberal diet—something which only one tenth of the American families have ever been able to enjoy, even in Coolidge days. Our laudable beginnings in social insurance legislation must be greatly extended to provide really ade-

quate unemployment benefits and to give better protection to old age. If persons over 40 can not find employment, which is now the case, the government must either support them by old age pensions, or provide work for them on public-works' projects. Twenty-five years is rather too long to wait on an empty stomach. The government must see to it that the benefits of scientific medical care are made available to every American. If this can be done by some form of private group practice, rather than by completely socialized medicine, so much the better. If not, the government will have to step in and set up a compulsory system of health insurance and state medicine. To support these indispensable extensions of governmental activity, we must provide for a realistic scheme of taxation in proportion to capacity to pay. The human budget must take precedence over the treasury budget.

These reforms may stagger many, but even they do not give any promise of permanently solving the problems of capitalism. We face an unpredictable degree of technological unemployment and an enormous increase in the efficiency of farming methods. Dr. O. W. Willcox has made it clear that we can produce all the food needed for a high standard of living with one fifth of the personnel now engaged in agriculture, cultivating one fifth the land now being actively farmed. And even he does not reckon with the future production of many basic foods by synthetic methods in the chemical laboratories, independent of contemporary agricultural enterprises.

If this brief summary of minimum reforms proves at all terrifying, let those who are scared turn to Germany or Russia and find out if they prefer conditions there to those changes which I have outlined. There is no alternative. If we are to follow the "middle way" between Fascism and Communism, then we must not hesitate to adopt the middle way. We can not get anywhere simply by viewing it from afar. If we hesitate too long, we shall have no opportunity even to try any middle way. As Max Lerner has warned us, "it is later than we think." We can not save ourselves from Fascism unless we move resolutely within less than a decade.

This brings me to what I believe is the most important observation I have to make, namely, if education is to assume social leadership it must cease to be satisfied with abstractions, however sound and benevolent. I have been reading over the three volumes just published by the Educational Policies Commission. As a summary of general principles they leave little to be desired. As a specific guide to what education must teach with respect to solving our immediate social problems they offer us little or nothing. It avails little to talk about the "abundant life" unless we can know just what we must do to secure the abundant life. We can not fight off the very concrete realities of Fascism merely by mouthing lyrical generalities about the glories of democracy and free business enterprise. Education must make clear its position with respect to such things as holding companies, monopoly, the labor movement, cooperation and the like. It has no hesitation in declaring itself against disease in the physical world; it must be equally willing to condemn political, social and economic evils. Education must not only teach us to think straight but also how to act straight in the midst of our social perplexities.

IV

How well does the American educational system of to-day measure up to the responsibilities thus imposed upon it by our critical age? The recent studies which have been made are, to put it mildly, not reassuring. We may first take up the verdict of educational experts.

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The already famous Regents Inquiry into the condition of public education in New York State, made it abundantly clear that the most expensive public school system in our country has failed to train our youth for citizenship, community life, remunerative occupation or competent further study.

The Carnegie Foundation for the Advancement of Teaching executed another comprehensive study, this time of education in Pennsylvania. This investigation of high school and college education revealed the fact that a quarter or more of those attending college in Pennsylvania were incompetent time-servers, without the mental ability to qualify them as intelligent and worthy college students. Believe it or not, a considerable proportion of them seemed to know less the longer they remained in college. Fifteen per cent. of them made a worse showing with respect to information in their senior year than in their sophomore year. Indeed, the least competent quarter of the college seniors knew less than the best third of the high school graduates. Interesting light was also thrown upon the competence of teachers in the state teachers' colleges. It was literally demonstrated that the best one fifth of the high-school graduates knew more than the poorest one fifth of the teachers they would study under in a state college.

We may conclude from these two highly competent investigations, which can hardly be accused of any Muscovite inspiration, that neither our high schools nor our colleges are producing anything to be proud of in the way of furnishing adequate training for the responsibilities of a democratic civilization.

We have already suggested that the functions of realistic education should be a highly selective conservation of the social heritage, a fair but resolute criticism of the social order, the formulation of a program for the improvement of society, and an indication of peaceful and intelligent methods of executing this program. Let us see how well education is executing these major social responsibilities of to-day.

Viewed in any broad and fundamental way, we must honestly admit that education blindly conserves the heritage from the past, without any important pretense to critical selection, save in fields of science and technology. With respect to our basic institutions and beliefs, our educational system conserves the past as completely and religiously as did the primitive council of elders and the tribal medicine men. Any resolute attempt to reject or discard fundamental items in our cultural heritage would immediately place in jeopardy any educational system or any body of educators. Indeed, the very proposal to do such would be regarded as rank heresy and a fit subject for investigation by the Dies Committee. Even our most daring educational reforms are, essentially, only superficial suggestions for improving the structure and administration of an educational system which is committed primarily to a reverent transmission of our ancient heritage.

There is also amazingly little criticism of our social order, though such criticism is absolutely indispensable if we are to discover those weaknesses which threaten the very existence of free and orderly society and are to recognize the alterations which are essential, if civilized decency is to prevail. We live in an age which has given unprecedented lip-service to the necessity and saving virtues of social research and organized investigation. We contend that "facts will talk," and we propose to let only facts talk. Tens of millions of dollars have been freely spent, no small part of this squandered, in order to investigate every conceivable type of secondary social problem. Yet, instead of actually letting the facts talk, our investigators have seen to it that disagreeable and challenging facts "shut up and pipe

down." Such facts as are played up are all too often the conventional, the self-evident and the platitudinous, so that much social research has been no more than expensive and pompous documentation of the obvious. Many of these investigations have been supported by funds derived from sources which would not tolerate effective and searching social investigation, or the clear formulation of the momentous conclusions naturally flowing therefrom. Indeed, most of our social research, timid though it may have been in drawing deductions, has been devoted chiefly to trivialities and details, and has rarely made any pretense to investigating the adequacy and efficiency of our basic institutions. Education has, thus, failed as signally in its critical analysis of our own social order as it has in a discriminating appraisal of the cultural heritage from the past.

The function of social criticism has been allowed to go by default to government investigators, journalists and free-lance economists and publicists. One has only to mention such representative names as Stuart Chase, Gardiner Means, Abraham Epstein, Charles Austin Beard, Herbert Agar, Lewis Mumford, David Cushman Coyle, George Seldes, Ernest Sutherland Bates and Alfred Bingham to realize the extent to which realistic social criticism is carried on outside academic circles. Not so long ago it was my pleasure and privilege to give a series of lectures before graduate students of education in one of our foremost schools of education. I was surprised to find that the students were actually thrilled and excited over information that would have been a commonplace to them in their junior high school period, if education were fulfilling its function in social criticism.

When we realistically examine the achievements of contemporary education in planning for a more equitable and efficient social order, we find that it has been even more deficient than in selecting what we shall accept from the past or in criticizing what we have to-day. When we appraise formal education from this point of view, realistic observers must admit that it is, quite literally, a liability to the human race—a veritable social disaster. Far from even indicating the desirability of a better type of civilization, organized education tends to breed reverence for the present social order. It distinctly and deliberately loads the dice in behalf of cultural tradition and social stagnation. It stimulates a spirit of social intolerance rather than an attitude of courageous experimentation. It tends to discourage even the minimum reforms necessary to preserve a democratic civilization.

We have made it clear that science and technology are widening and deepening the already menacing gulf between machines and institutions. Yet the prevailing attitude of most scientists and engineers is one of social quietism. Our scientists tell us that science may create unprecedented material advances and social maladjustments, but it can not furnish us with any immediate, direct and authoritative guidance as to how to meet these problems with expert intelligence. This is the message of the recently elected president of the American Association for the Advancement of Science,[1] himself one of the outstanding American social scientists. The scientists are quite willing to assume the responsibility for "advancing science," but they hang back when it comes to "advancing society." They ignore or evade the obvious fact that, unless our social institutions overtake scientific and technical achievements, all will go down together in a common ruin before many generations have passed. Certainly, if science can not lead the social procession nothing can. For those who wish to follow out this line of thought I would com-

[1] W. C. Mitchell, "Science and the State of Mind," *Science*, January 6, 1939.

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mend the stimulating book of Robert S. Lynd, entitled "Knowledge for What?"[2] a much needed and resolute arraignment of the quietism and evasive philosophy of our intellectual leaders in the social studies movement.

Not only does organized education fail to execute its indispensable function of social guidance; its leaders even assume an attitude of savage hostility and professional intolerance toward the few educators who realize their social responsibility and make even a faint-hearted effort to do their duty. Donald Slesinger tells us that not one prominent professor who has been dismissed for his liberalism and later vindicated by the American Association of University Professors has ever again been able to secure a satisfactory academic appointment. And it has been the professors, rather than presidents and deans, who have been responsible for this scandalous state of affairs. Yet, when we examine the content of the teachings of these so-called subversive educators, we find little cause for any alarm—unless it be the discovery that they are, all too often, merely false alarms.

Our educational sociologists have stolen no thunder from Stalin, or even from Norman Thomas. At the best, they are only giving us what Lester F. Ward said more candidly and far more thoroughly over fifty years ago. Even John Dewey, rightly regarded as our most stimulating and progressive educational theorist, rarely presumed to get explicit in the matter of social guidance until he left the profession of education for that of active political agitation. When Dewey entered the political arena he gave us something that we can actually bite into. But not even one out of ten of Dewey's ardent pedagogical disciples has the slightest familiarity with Dewey's doctrines, expressed as a leader of the League for Progressive Political Action and the People's Lobby.

The timidity and irresolution of even our progressive educators can be illustrated by an example well known to some in this audience. That excellent journal, *The Social Frontier*, presents a very moderate social reform philosophy, advocating only the very minimum of changes which might be expected to make the present social order workable. Yet, a number of our most publicized and most popular educational leaders have taken the editors sharply to task for their alleged radicalism. And, in turn, some of those associated with *The Social Frontier* recently gave evidence of acute alarm over so indispensable and so mild an organization as the American Federation of Teachers.

One of the most notorious examples of sham and hypocrisy in the campaign against our quasi-liberal educators is the hue and cry against indoctrination. It turns out that indoctrination is nothing more than the teaching of moderately liberal ideas with respect to education and social reform. This charge is never raised against those educators who inculcate with a far greater degree of smug dogmatism the most reactionary social and educational conceptions. Indoctrination, as an epithet, turns out to be no more than the pedagogical adoption of the "name-calling device," so widely employed in contemporary propaganda.

Whatever the important and worthy services of liberal teachers to other aspects of education, it is no exaggeration to say that there is not one prominent educator in a responsible and reputable academic post in the United States to-day, who is devoting himself primarily to teaching the essentials of a better social system or telling us how to effect the transition from our own social order to a more desirable one. And if such an educator should suddenly arise, he could not hold his position for six months, if his activities and teachings were noised about. Our educators, even our most progressive educators, are primarily interested in saving their jobs, not in saving civilization.

[2] Princeton University Press, 1939.

For this I do not blame them especially, but they should not ignore the long-time consideration that, if we have no civilization, we shall have no jobs for anybody, least of all for educators.

Right now, one of the most discussed aspects of the social responsibility of education is that of preserving democracy in the face of the challenge of totalitarian dictatorships. This subject has been discussed with intelligence and realism by President Clarence A. Dykstra, of the University of Wisconsin, in his presidential address before the National Municipal League last December. It is entitled "Democracy at the Crossroads," and is reprinted in part in the January, 1939, issue of the *National Municipal Review*. President Dykstra suggests that, if we wish to preserve democracy in the United States, we must take a leaf out of the dictators' book, so far as mass education is concerned. To-day, we have the problem not only of improving democracy, but even that of maintaining what democracy we have at hand. If we are to succeed in this twofold task, we must muster all the resources of mass education and direct them to this end. As President Dykstra puts it:

> Perhaps one of these days we shall have to decide that even here in the United States all of our educational facilities—schools, press, radio and the screen—will have to be marshalled together in an effort to give the American people an understanding of the problems facing our civilization and our democracy. . . .
>
> If we still believe in democracy perhaps the world situation warns us that we must develop at least for a time a conscious educational program which will give democracy a chance for survival and for demonstrating that it can meet the challenges inherent in modern life. . . .
>
> It is a common saying that eternal vigilance is the price of liberty. If, then, freedom and liberty be worth struggling for, let us use our far-flung educational and communication devices to help us in that struggle. The freedom of these agencies themselves may be at stake.

As an abstract formulation of the situation, one could hardly improve upon President Dykstra's statement of the case. But it is necessary to remember that democratic and capitalistic society must be reformed and made workable if it is actually to be preserved. We shall get nowhere at all merely by parroting the threadbare phrases of traditional democratic propaganda. If democracy is not reconstructed in such a fashion as to adapt it to the responsibilities of our age, no amount of fulsome praise or intriguing rhetoric can preserve it.

President Dykstra is a very liberal and courageous university president. But I think I may be permitted to hazard the doubt that he would appoint to a social science professorship any man with a public reputation for daring to state clearly the essentials of a social program which would preserve American democracy. If this be true of President Dykstra, what shall we say of the averagely liberal American university executive, one of the most famous of whom was overheard recently lavishing hearty praise upon the stalwart Americanism and salutary statecraft of Mayor Frank Hague of Jersey City?

There is a still further obstacle in the way of using education as an instrument for operating and maintaining democracy. I believe it is not at all unfair to observe that even the Carnegie Foundation for the Advancement of Teaching would itself be acutely and vastly alarmed over the introduction of a curriculum which would make democracy operate effectively. As Horace Coon has suggested in his important study of foundations, "Money to Burn,"[3] truly democratic government and education bring forth from our foundations the pained cry that we are trying to destroy both education and research.

Indeed, the whole conception of education in the role of social leadership constitutes a definite paradox. Education is supported, for the most part, by those who vainly wish to preserve the existing social and economic order intact. How

[3] Longmans Green, 1938.

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can we expect those who support education to encourage teachings which will undermine and modify the present scheme of things? Obviously, only by convincing them that essential reforms are the most certain way of preserving what can be saved from the impending wreck of the present social order—that reform is the safest way. But even such a campaign of persuasion is both dangerous and difficult, a fact amply demonstrated by the reception accorded to the New Deal by the vested interests.

Even those educational investigators who are realistic enough to point without hesitation to the defects of our current system of education have little to offer us, except suggestions as to the improvement of school administration and the introduction of economies in school finance. They talk in attractive generalities about the necessity of realistic training for citizenship and better community life. But it is rare that they ever become explicit as to what this actually involves with regard to curriculum content and the security of educational tenure. Even when entrusted with this task, educators are likely to prove something less than resolute. I was once a member of the committee which prepared the annual yearbook for the Department of Superintendence. It was entitled "The Improvement of Education for Democracy," and was dedicated to the memory of Horace Mann. It contained an extremely restrained statement of considerably less than the absolute minimum of realistic educational reforms necessary to make democracy workable. Yet it was denounced as radical and incendiary by leading educators, drawn from some of our most advanced schools of education.

Educators might just as well understand, once and for all, that we can not save democracy through education, unless we are willing to teach in our schools the materials which are essential to the salvation of democracy.

V

To sum up, we may say that American educators face two very definite and realistic alternatives. They can arouse themselves to the social responsibility of education, teach realistically and courageously those things which are essential to the preservation of democratic civilization, and organize themselves with sufficient coherence to make sure of their tenure while thus engaged. They may not succeed, if they literally shoulder the current social responsibilities of education, but at least they can go down fighting, having the satisfaction of knowing that they "kept the faith and fought a good fight," and that they did not abandon their ship while under fire.

If our educators refuse to take such steps while there is yet time, it is almost inevitable that some form of regimentation, roughly similar to European Fascism, will settle down upon us. Then, the condition of American educators will be unhappy indeed. Many will lose their positions, for, under Fascism, education is a much more simple and direct affair than under democracy. No such extensive and diversified personnel is required. Those who remain employed will be parrots in the classroom, and professionally a cross between "kicked dogs and scared rabbits." And this condition is not far off. When I was personally very familiar with Germany and the Germans a decade ago, Adolf Hitler was inconspicuous, even if compared with the current repute of our second-rate champions of Fascism. He was literally an unknown, when compared to the popular vogue of men like Father Coughlin to-day.

What I have written may be offensive to many. But I venture the guess that my remarks may appear more cogent and acceptable to such persons, in case they rub elbows with me in a concentration camp ten years hence. But then it will be a little too late.

CULTURE: A SCIENTIST'S IDEAL

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For centuries men of letters, theologians and philosophers have thought and written in terms of those changing aspirations of an unfolding civilization that together form the history of the meaning of culture. For culture has had as many meanings as there have been minds that have speculated in a diversity of idealism so broad as to include both the crassest worldliness and the finest spirituality. Thus, on the one hand, the ideal of culture has been the glorification of man and the bold expression of all his hopes and wants; it has been the gratification of his senses, his quest for pleasure. Yet, on the other hand, culture has been the inspired exaltation of the supernatural and the sternest repression of desire; it has stood for the severest asceticism. Indeed, culture has ebbed and flowed like the ocean. It has whirled in the pleasure-bent eddies of hedonism; it has thundered the relentless dogma of religious fanatics; it has rippled gently in fresh breezes from Rousseau and Tolstoi; it has rested in limpid calm, reflecting Herder's vision of a higher nature and the intellectual freedom of Kant and of Fichte.

With the development of general education and the growth of scientific knowledge, the interpretation of culture became the province of the centers of learning. The German universities founded upon the principle of academic freedom and critical inquiry an ideal of scholarship which, in stressing creative thought, was destined to dazzle the world with its contributions to knowledge. In Britain grew that great tradition, the "liberal education" of Oxford and Cambridge, with its emphasis, following Plato, on "learning, morals, and manners." But the war and its consequences have left Europe staggering intellectually as well as morally; and there have arisen philosophers of despair who speak not merely of economic crisis and social upheaval, but, more significantly, of complete cultural decay. Thus, while on the European continent education has become merely a stern training in nationalism; in America it might almost be called an "activities racket." Thomas Huxley, in defining a liberal education, demanded that youth be trained so that it could work with ease and pleasure. But is not the work often forgotten in a philosophy of "painless education" which strives to make life a Walt Disney rhapsody in sugar-coated pills? Does not youthful laughter often echo with a blustering and ignorant conceit characteristic of languishing intellectual integrity? In this same spirit of self-deception culture has been defined to be "what is left after you have forgotten what you learned." And in the measure that dabbling aimlessly in many fields has become the approved process of learning, there is ever less and less to forget, and ever fewer find contentment in the mastery of even small things. In American colleges the liberal education of the English tradition and the scholarship of the German are often little else than travesties. Manners and morals are neglected, while learning is held synonymous with a graded superficiality that substitutes surveys and ready-made orientation for deeper knowledge. The ideal of general culture has, thus, degenerated into a peculiarly complacent pride in labelled mediocrity. Indeed, it has become like a swollen pie-crust that stretches a nicely browned and sugared surface over much hot air and a few berries lost in blue juice. Why bother about ideals when one can live? Why work when one can have fun? Can not the

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practical mind be free and happy without the smugness of book-knowledge, without airs of refinement, without the stamp of a liberal education? But even the self-styled man of culture, blind to a historic tradition of adventurous thought, demands an idle place in the scientific sun. And while despising vocations, the mob, the labor problem and all machinery, he seeks consolation in the words of Powys:

> The cultured mind approaches everything through the imagination already charged with the passionate responses of the great artists; so that what he sees is a fragment of Nature double-dyed so to speak, a reach a stretch of time's whirling tide, that carries upon its chance-tossed eddies the pattern of something transitory and eternal.

While admiring the glitter of these mysterious words, those who are accustomed to view nature more intimately, more simply and less colored by wishful fancy see no whirling tide. For them the ocean of culture has ebbed to leave only brown mud-flats full of squirting clams and dotted with screeching gulls. White sails are furled; the clipper ships lie rotting. Will the tide ever run in again?

In seeking an answer to this question let us leave aside the passions of the great artists. Let us be impassionate and look at culture not only as a beautiful tradition, but as a hope of to-day for to-morrow. Perhaps, viewed more personally and more modestly, it need not be an impossible ideal; perhaps it can be more than a static state that old-fashioned people like to look back upon. True, it is difficult to forego that flourish of rhetoric, which to so many is the very essence of the idea of culture. And it may seem especially bitter to the artist actually to descend to earth to seek a tangible meaning for culture in the simple statement, "Culture is the working of the ground in order to raise crops."

Thus to define culture in terms of its most primitive origins is suggestive of agriculture, where the ground to be worked is the fertile but dusty earth; where the crops are just plants selected for a single vulgar characteristic—usefulness; where the work is hard and dirty—plowing, harrowing, seeding. But culture did not grow from a double-dyed fragment of a wave-tossed nature; it grew first from learning the meaning of usefulness, from distinguishing between weeds and valuable crops. It developed with intelligent and purposeful tools; it prospered with a slowly and painfully acquired knowledge of how to select seed from the more vigorous of the most useful plants.

Floriculture resembles agriculture in that it, too, grows plants in the earth, works over them with spade and hoe. But its aim is not usefulness. It seeks through patient and intelligent labor to develop flowers that will bring a special delight to him who approaches them, breathes their fragrance—the delight that men call the experience of beauty. Perhaps this form of culture will evoke the passionate responses of great artists, but fundamentally it is still agriculture, still the same working of the ground for a purpose, the same deliberate and studied attempt to control environment and understand heredity in order to find the satisfaction of greater usefulness, discover the joys of new beauty. And its success is not the result of indolent disinterest or careless superficiality, but of consistent learning from experience.

Self-culture is like agriculture and floriculture in ideal and in method, but it must work another ground with different tools and for a loftier purpose. In self-culture the ground is the conscious self with its environment of a living body and of the great physical world in which it moves. The crops are ideas charged with intrinsic worth; the work is the intelligent use and development of the tools of experience and knowledge; the method is that of science. The problem at hand is to examine the ground, this conscious self; to study the tools with which it may be worked; to think upon the crops, the

ideas, which may be raised. Is scientific self-culture possible? To what extent can an individual control his environment, coordinate his inherited talents and qualities to formulate and achieve his own ideal of worth?

The Ground

Whatever culture has been or may yet be, the immediate soil in which it grows is human personality. But an introspective awareness and a consciously analytical contemplation of self dawn only slowly upon the maturing human being. And what is eventually revealed in cognition is then inevitably and deeply colored by prejudice and habit. Thus, to venture to examine self first brings discovery and delight, then confused reluctance and increasing wonder. For across the threshold of the primary experience of self, of sense-perception, consciousness and cognition which unreels like a cinema upon happiness and pain, upon contentment and sorrow, is a startling and mysteriously complicated interplay of mental processes. There is memory which reenacts as upon a stage the nerve responses of the past. There is thought which combines and builds out of mere sensations stupendous edifices in abstraction. Such are beauty, truth and goodness: all patterns and sequences vaguely assembled by nerves stimulated by wave-trains originating in the physical world. Finally there is will, that seems to compel action according to an unknown scheme in a greater nature and which would yet offer conscious choice.

Surrounding and inseparably a part of this psychological world is a body composed of cells which grow and reproduce, which are strangely and powerfully linked with a dim past of untold ancestors. They are combined into a coordinated and integrated organism of complexly related, self-sustaining parts that are sensible to many and varied stimuli. These, in turn, lead to reactions in the form of sensation, of motion, of action and, after much repetition, of habit.

This entire biological-psychological structure is imbedded in an external environment of a social and physical world. Thus there are other human beings—parents, teachers, friends and foes. From them are acquired by persistent imitation, habits and prejudices and mental pictures in that scheme of custom and tradition which is society. There is the vast panorama of nature, of animals, plants and the inorganic; there is light for the eye, heat for the body, sound for the ear. And there are composite, man-made things—toys, machines, instruments for performing a million tasks; there are books containing mysterious treasures for the imagination.

It seems obvious that the conscious self, including its environment, is not simple to fathom or to analyze; yet some understanding must precede any attempt to control. For control is merely the ability to predict. To be sure, the study of human personality has always been the wonder of philosophers and the object of much detailed study by innumerable writers, seeking to portray the essential characteristics of their fellow men. And the literature of many lands is replete with character studies often revealing extraordinary and uncanny insight into human conduct as a problem of the coordination of an inherited nature with an uncontrolled and seemingly uncontrollable environment. Great as have been the contributions to the study of human nature of literary, historical and sacred writings, the information so presented is more interesting than it is exact; it is qualitative and general, rather than quantitatively specific. From it nothing may be predicted with certainty, for it attempts to give only a synthetic cross-section of types, not an analytical and functional study of individual personality as a part of a universe governed by natural law. It has been and continues to be the particular task of science

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to pursue such a study. And scientific advance has been nothing short of phenomenal in some fields; in others little more than a beginning has been made. Thus the physical-chemical sciences have probed deep into the properties of inanimate matter with signal success in predicting and controlling its behavior. The physiological and biological sciences have studied the characteristics of life processes, of evolution and of inheritance. While learning much that is of the most fundamental significance, they have as yet not penetrated into the mysteries of the auto-synthetic and auto-attractive properties of the ultimate particles of life, the genes. Psychologists, anthropologists and sociologists have struggled manfully with the extremely complex psycho-physical make-up or personality of individuals and of groups. By many approaches they have sought to disclose some of the deeper secrets of consciousness and of mental processes. But their task is hardly begun. And each individual, interested in a practical scheme of living, finds even the most modern science able to contribute little more than an optimistic attitude instead of essential knowledge about mind and body as a functioning unit in a personality-moulding environment. Inevitably he senses that mankind is pathetically ignorant, and he wonders whether the whole idea of scientific self-culture is not premature, whether mysticism in one form or another is not to be preferred. For it is still extremely difficult for even a keen intellect to view himself as a part of a natural order subject to natural law. It seems reasonable enough for the physicist, the chemist, or even the geneticist to control certain forces of nature or at least predict their behavior from mathematical formulae. But to picture himself as consciously and deliberately planning his own road to what is worth while startles him, even frightens him into believing that there is greater hope and comfort in the passive faith of ignorance.

Tools

Each human personality, when it attains the maturity which finds interest in the problems of self-culture, is the product of a complicated sequence of interactions depending upon heredity and environment during those formative years over which the individual had no control whatever. What he does and thinks to-day is thus indeed the outcome of all his yesterdays. But is not that a key to the future? Personality does not change abruptly; but must not its development be deeply influenced by always seeing each to-day as a yesterday for to-morrow? Can it not be encouraged to grow more like wheat in straight furrows planted to-day, instead of like weeds scattered by the winds of habitless chance? The answer lies with the individual sensibility to experience and knowledge, with the tools of self-culture; and with the hand that must guide them, with intelligence.

The basis of experience is perception. This does not depend only upon immediate sensation, but also upon images in memory and, in particular, upon that mental activity which discriminates and recognizes. Thus, although it be not possible for an individual to predetermine his environment in any general sense, he can certainly deliberately set out to observe some things with attention, to pass others by completely or superficially. He can not always select what he wishes to forget, and then forget it; but he may well choose what he will remember, and make that the food for his thoughts. And thinking, he may reject one subject in order to dwell more deeply on another. In this way he may exercise intelligent selection in the development of intellectual as well as physical habits and taste. Experience, in brief, is a tool which moulds personality. It has its special characteristics and, of course, its limitations. Like every other tool it can be used and misused. It can be handled expertly and with grace, or clumsily and

without care. Each man must use it, whether he will or no. But only a few try to learn its secrets in an attempt to develop a technique for using it effectively in the practice of self-culture.

Knowledge is a special kind of experience. It is the history largely of other people's discoveries translated into the language of one's own thoughts. It is a master tool with which one may learn to use immediate experience to greater advantage. With it thoughts may be developed and guided; memory may be stocked; perception itself may be enlarged to include a new freedom acquired only through knowledge of natural law in the broadest sense. For when there is consonance between man's habits of thinking and willing and an observed consistency in nature, the experience of freedom is boundless. It is the aim of science to achieve this freedom by discovering processes of thought which express the consistency or permanence actually observed in nature in a general and useful form. Hence, if the ideal of self-culture is still the old "Know thyself," its meaning may be made scientific. For to have formulated the laws of nature, is to have found the key to harmony in life and to the discovery of what is preeminently worth while.

Without intelligence experience is wasted and there can be no knowledge. A man's intelligence is a part of his inheritance; it is a link in the evolution of the human species. To possess intelligence is to be capable of learning to guide the tools of experience and knowledge in the interest of self-culture. Few habitually take advantage of this faculty to develop technique and to build new habits of skill; many let it wither and die.

To work the ground in self-culture is far more difficult than in agriculture, for the seeds of worth-while ideas have never been discovered. Fortunately, thanks to keen observers, a little is known about the conditions most favorable to their appearance as if from nowhere. And each individual can learn much about his own personality by careful observation and judicious experiment. The great mathematician, Poincaré, has given a formula for his own case, and many a scientist has learned its value. Poincaré discovered that while new and significant ideas grew most readily when his mind had been deeply saturated with a subject, they ripened to maturity more often in the clear air of complete distraction. Thus, to work the ground truly is to study deeply, to use experience and knowledge with a maximum of skill. And then, when all may seem to have been in vain, to relax, to forcibly hurl consciousness into the refreshing environment of wholesome pleasure. Then, if the preparation has indeed been adequate, ideas may begin to appear as if by magic, thoughts gather, and the ecstasy of creation and discovery will fill the whole being with its dazzling light. Presently it will grow dim, and the time will have come for weeding and systematic cultivation. The new thoughts must be examined critically; they must be studied on the basis of experience, analyzed in the cold gleam of objective knowledge. What is unworthy may then be rejected; what seems truly worth-while must be retained, developed, allowed to take root and grow into new habits, for that is the ideal of self-culture. In the words of Goethe: "Eine schiefe eigene Meinung bringt der Erkenntnis naeher als eine uebernommene richtige."

The Crops

In agriculture one seeks useful plants; in floriculture those characterized by beauty. In self-culture the purpose is to develop ideas charged with worth. But what is this usefulness? What is beauty? More particularly, what constitutes worth? These are all abstract and relative terms signifying certain groups of nerve-cell reactions characterized in a recognizable and distinctive way by each individual sensibility. Thus, there are

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experiences which produce the sensation called beauty; there are others that lead to that called usefulness; and both may be included in a single, more general group as characterizing two aspects of worth, meaning desirability. And what will or will not be so grouped depends in the last analysis on each personality. In general, however, there is wide-spread agreement on many experiences leading to individual sensations called beauty or usefulness. In agriculture, then, worth-while means useful; in floriculture it means beautiful; in self-culture, on the other hand, it seems convenient to distinguish four broad and overlapping sensation-groups which may be called the qualities of worth. They are, first, the essential quality of usefulness; second, the esthetic quality of beauty; third, the rational quality of truth; fourth, the moral quality of goodness. Of these four qualities the first two, emphasizing things to be done or achieved, are essentially artistic in nature. They may be associated, respectively, with the practical and the fine arts. The last two qualities, on the other hand, concern themselves principally with method and with knowledge. They are thus scientific in nature, and are related, respectively, to the natural sciences, mathematics and logic in the first, and to ethical science in the second. To understand worth, then, as the characteristic ideal of self-culture, means to have broad experience in these four qualities. In themselves they critically encompass all human experience and knowledge; they suggest many fields as yet hardly touched.

The quality of usefulness is associated with practical things. In a restricted sense it means the fulfilment of essential wants which, in the modern picture, include food, clothing, shelter and comfort. But in a larger sense much of human civilization is an expression of usefulness. For its professions, trades and practical arts; its instruments of government and law, of education, of commerce and of industry are dedicated to the end of service. It is in this broad and comprehensive sense that usefulness is described as the essential quality of worth. It is the foundation of life in a society; it is prerequisite to physical and mental living. But usefulness is not synonymous with worth; it is but one of its qualities. And that utilitarianism which would make utility the only significant characteristic of genuine worth is either still buried in the primitive past of a stone age, or it has descended to the insipid comfortism of to-day. What is useful to man and society must always be pre-eminently worth while, for it includes all that is related to the direct control of experience. But a broader vision of an enlightened self-culture will seek and find values transcending far that of usefulness alone in its plan of creative achievement.

The esthetic quality is derived from primitive responses to pleasure. But in an integrated and highly organized social structure with its problem of human relationship, pleasure is a complex experience associated not only with direct sensation, but also with cognitive sequences and coordinations. Beauty is, thus, an experience not only of physical pleasure, but more especially of emotional and intellectual enjoyment. Beauty in physical things, for example, is characterized by color, shape and proportion; beauty in literature depends upon style, diction and motivation; beauty in science involves simplicity of structure, clarity and coordinated symmetry; beauty in human relationships is associated with fairness, loyalty, unselfishness and cultivation. But always beauty is a personal discovery, and as such it is essentially relative. Its definition by an individual depends alike upon his refinement in sensibility and upon his breadth of experience; its perception is intimately related to his manner of approach, to his attitude toward problems of self and society. Just as there are modern utilitarians who

dogmatically identify worth with utility, so there are the old aristocrats of culture that like to associate it exclusively with beauty. More significantly, culture from their point of view is not a conscious striving for a purpose, but rather a fait accompli, a static condition of conventional form in manner and of traditional point of view. Even as the utilitarian is emotionally in a stone age of food, clothing and shelter, so these white-collared gentlemen of etiquette are intellectually still in the Victorian age of belles-lettres. Beauty as a quality of worth must burst such corsetted dogmatism if it is to lead in a modern quest for self-culture.

The experience of truth is the climax in the exercise of reason. It is a cognitive reaction so unique and characterized by an intellectual exhilaration so unmistakable that there is strong temptation on the part of those who know it well to elevate it to a favored place among the qualities of worth. In meaning, truth is not rigid and static, as many would have it; it is no unchanging principle of an eternal universe. But rather, it is relative, like beauty; like usefulness it depends upon the time in history, upon circumstance and especially upon the sensibility of the individual who perceives it. For truth is continually being made and modified by experience. A new truth is accepted and an old one is rejected as a mistake if the cognitive processes are so better served. To be sure, it is at times pleasing and impressive to maintain that truth exists continuously though unknown, floating vaguely in an abstract universe as an absolute and unknowable ideal. But in the language of science such evidences of lofty desire serve no useful purpose; for each scientific observer, truth must be primarily the claim of a particular moment and place in his cognitive experience. And the personality of each individual unmistakably reveals itself in the postulates he sets up as true and in the evidence which he accepts as convincing test. The scientist attempts to establish the truth of a hypothesis by the systematic observation of its consequences in a planned and controlled experiment. The religious thinker, proceeding in a fundamentally similar method of also seeking verification for beliefs and doctrines, often depends upon experiences so deeply and unalterably colored by faith in the very postulates he seeks to verify that the test loses all meaning. Science, too, has faith, but it is not faith in postulates. It is faith in a method for defining truth specifically in terms of directly observable consequences. Thus, by establishing a correspondence between abstract mathematical thought and direct experimental observation upon periodicity in natural phenomena, the mathematical-scientific method was developed as a means of defining truth in terms of a predictable consistency in nature. In this way qualitative understanding was augmented by quantitative knowledge; a vague and imaginative ideal of truth was elevated in science to a well-defined intellectual experience. In other fields of human activity the meaning of truth is still often associated with man's ignorance rather than with his knowledge, however limited that may be. Such an irrational worship of vagueness has nothing in common with truth as a fundamental rational quality of real worth, as a cognitive experience that reveals harmony and order in the mind's description of nature in the broadest and most inclusive sense.

The moral quality of goodness has not been illuminated by a development of ethical science comparable with the phenomenal advance in natural science. But, as in the case of truth, the meaning of goodness at any time and place depends upon its observed consequences as interpreted and accepted by each individual himself. Thus the mystic is inclined to seek evidence as to consequences in terms of personal intuition which he believes to be either directly inspired by the supernatural or indirectly revealed in sacred

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writings and customs. The realist, on the other hand, establishes more worldly tests in the form of rational and practical codes of ethics built upon direct observation and adjusted more or less successfully to the needs and exigencies of the time and place. Finally, many another projects human ignorance into infinite spaces of thought, calls it God or Virtue, and worships it blindly or fearfully as the ideal of combined truth and goodness. For such a devout the very quest for self-culture must be heresy. Thus one is led to wonder with Malisoff, "whether the truer prayer occurs before a shrine or before a magnificent illumination of human intellect." As a quality of the ideal of worth, as a characteristic of the very purpose of self-culture, goodness must belong to the human intellect as the guiding inspiration of a yet undeveloped ethical science. As a recognized and valued experience it must join in synthesis and harmony the qualities of usefulness, beauty and truth. For what is truly worth-while must have a consistent meaning in the mind of each worker in self-culture. It must encompass his most valued experiences in memory, his loftiest ideals in imagination; and both must rise from the still small foundation of scientific knowledge. Worth, so qualified, is to characterize the crops of self-culture, those ideas grown in the soil of consciousness by an intelligence guiding the tools of experience and knowledge.

The Ideal

In the furrows of the earth is written a meaning of culture that is as lofty in its idealism, as naïve in its simple faith and as uncompromising in its tireless industry as science itself. It is a dynamic reality, not a static memory. It demands creative effort, not merely a languishing veneration of a beautiful past. It is measured not by the elegance of a man's language or attire, not by what he has forgotten or still remembers, not by passionate responses inspired by great artists, but by his own ambition, by his own attitude toward his to-morrow. It builds upon intelligence, upon the skill and experience of to-day and the wisdom and knowledge of yesterday a plan for enthusiastic, vigorous creation. Scientific self-culture is still a hope rather than a completely realized method, but as such it is a true guide for him who labors with facts against prejudices, who walks modestly but courageously and confidently toward high places. Culture is a quest for vision and understanding; it is planful living. Culture is the working of the ground in order to raise crops; it is the conditioning of the conscious self to understand and to create what is worth while.

Let there be a regeneration of such an ideal of culture, and it will bring with it learning, morals and manners. For it is an ideal of self-respect and of planned achievement, that grows not on those broad vistas of sand swept by the changing whims of educational fancy, but in the fertile valleys of individual experience, in the deep channels of personal knowledge. Let those who would be cultured seek more than a shell of form; let them be inspired by the will and the intellectual freedom that grows from profound understanding and consummate skill; let them study the technique of planned living; let them seek what is truly worth while in all things as usefulness, as beauty, as truth and as goodness. Then they may thrill to the wonder of creation and discovery, and so become conscious partners in the unfolding of civilization. All culture ebbs and flows with self-culture. Over the mud of intellectual indolence and spouting superficiality must rise the relentless tide of scientific truth. Then, over deep blue waters the white sails of trained and enthusiastic intellects may strain before an ever-fresh wind from the Great Unknown.

AMERICA'S CHEMICAL HERITAGE

By Professor HARRISON HALE

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Not every American chemist, busily engaged in his daily tasks, realizes the heritage that is rightfully his. From the very earliest days of the white man's life in America chemistry has been a factor in this country's growth and development. Since the World War its increasing importance has commanded the attention and respect of every American who thinks. America's chemical heritage includes this record of past achievement, present-day accomplishment and hope for the future. To present this satisfactorily one must of necessity rival the speed of the lamb, which, it was claimed, could run sixty miles an hour, since only at this rate could the lamb keep up with Mary to-day.

In the opening sentences of his "Histoire des Doctrines Chimiques," Wurtz wrote: "Chemistry is a French science. It was founded by Lavoisier of immortal memory and its most lasting contributions have been made by his countrymen." Naturally such a statement was a basis of angry controversy and dispute. This was more than half a century ago. Only a few years ago Philipp Lenard, Nobel Prize winner in physics, published the first volume of his "Deutsche Physik," dedicated to the German Minister of the Interior. In it the statement that "Science is and remains international" is declared to be false. And Lenard was awarded the Franklin Medal in 1932 in recognition of a "life work devoted to fruitful research in physics."

Johannes Stark, also Nobel Prize winner in physics, takes the same position in an article on "The Pragmatic and the Dogmatic Spirit in Physics" published in the British journal, *Nature*, in 1938, making an attack upon the Jews. More than 1,200 American scientists registered a vigorous objection. Not in any spirit similar either to that of the Frenchman or of the German is America's chemical heritage presented.

Rather do we agree with the position taken by another German, Nobel Prize winner in chemistry, as stated in his "Die Forderung des Tages," published in 1910. Here Wilhelm Ostwald declares, "Of the things that mankind possesses in common, nothing is so truly universal and international as science." In chemistry as in other fields of endeavor, we in the United States owe very much to the other countries, not only for ideas, but for men who have helped in the development of these ideas. Surely science should transcend nationalism, for science is founded upon truth, which knows no national boundaries.

Yet America does have a chemical history and heritage well worth knowing. In his "Novum Organum," Francis Bacon (1561–1626) said, "The true and lawful goal of the sciences is none other than this: That human life be endowed with new discoveries and power." When we recall that about the time this was written the early permanent settlements in America were being made, the statement seems prophetic of the developments and achievements to be made by chemistry in this new land. From Charles A. Browne, a foremost authority on American chemical history, we learn: "The London Company, the year after they founded the Jamestown settlement, sent eight Poles and Germans to the new colony to make pitch, tar, glass, and soap-ashes. No sooner had these workmen landed than they began operations. From this small beginning in 1608 we now date

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the commencement of chemical industries in America." These products were among the earliest of American exports.

Expansion of chemical industries was even then in evidence, for 150 men were sent out in 1620 to set up three iron works. Salt works to supply the Atlantic coast fisheries were established, and lead smelting was progressing. But, "all industrial efforts were paralyzed by the Indian War of 1622."

In April, 1935, in New York City, the American Chemical Society held its largest meeting with a group claimed to be the greatest gathering of chemists ever assembled, but not necessarily the gathering of the greatest chemists. The 300th anniversary of the work of John Winthrop, Jr., in industrial chemistry in America was celebrated. Winthrop actually had a laboratory and a library in the Colony of Massachusetts and made chemical tests. He projected the manufacture of salt, saltpeter, pine-tar, glass, potash, iron, copper, alum, gunpowder, medicines—a rather ambitious program. He actually produced only the first three. Of his library, 270 volumes have been preserved, some of which were exhibited at the New York meeting. Some one has said, "Chemistry is a young science but an ancient art." At Jamestown there was the art of chemistry, in New England the beginning of the scientific side. From these early beginnings, sometimes aided by outward circumstances and sometimes hindered, chemistry in America has steadily grown until it occupies a preeminent place and gives still greater promise for the future. As the Irish say, its advance has been steady by jerks.

Not only is this true of material development, but it is true of the intellectual and theoretical side, because it is obviously necessary that the two must go hand in hand. To change the simile, if chemistry progresses upon the two legs of industry and research, then it is necessary that each of these must develop equally unless its progress is to be grotesque. The United States, with approximately 6 per cent. of the world's population, has a chemical production approaching 60 per cent. of the world's total. It is not yet so high and may not reach this figure, but it was placed at 47 per cent. in 1927 by an authoritative German source, and there has been much progress since then.

Modern chemistry is sometimes dated from the discovery of oxygen by the Englishman, Joseph Priestley, in 1774. Twenty years after this discovery Priestley came to Pennsylvania. Here he lived for the last ten years of his life and there in Northumberland his grave is to-day, a constant reminder of the inspiration which he brought. Priestley's discovery would have lost much of its significance had it not been interpreted by Lavoisier and its importance shown. It is most interesting that the founder of the du Pont Company learned the art and the science of powder-making from this distinguished Frenchman.

In *The American Chemist* for April, 1874, Dr. H. C. Bolton, of Columbia College, called attention to the importance of 1774 in chemical history, stating that "the year may well be considered as the starting point of modern chemistry." Note was made of the discovery of oxygen by Priestley, "the immediate results of which were the overthrow of the time-honored phlogistic theory and the foundation of chemistry on its present basis." Dr. Bolton suggested a centennial celebration on August 1. This suggestion was endorsed by the editors, who asked interested chemists to "send their views at once so that the project could be put into practical form in time. In response Miss Rachel L. Bodley, professor of chemistry in the Woman's Medical College of Pennsylvania, suggested Northumberland as the most appropriate place. A call for a two-day meeting, be-

ginning on July 31, was issued and seventy-seven chemists met. They elected one president, Charles F. Chandler, of the School of Mines, Columbia University, and thirteen vice-presidents. At this meeting the organization of a chemical society was discussed, but no action was taken in deference to plans for "establishing a chemical section" of the American Association for the Advancement of Science. The idea, however, was not dead and the American Chemical Society with 133 members came into being in New York City in April, 1876. What it has become in the past sixty-two years is worth our knowing.

To give the history of this, the largest of the chemical societies, in any adequate form would take far too much time. From the beginning women have been admitted upon the same terms as men; at no time has there been any distinction because of sex or of sectionalism. Its first president was from New York and its second from Virginia. It is an unusual privilege that is offered to American chemists to become members of this society, which has done so much for chemistry. Its publications far surpass those of foreign chemical societies in the amount produced and in the low cost for which they may be obtained. Dr. Harrison E. Howe states that "to read aloud, word for word, at reasonable speed, the material which is published annually by the American Chemical Society alone, exclusive of *Chemical Abstracts*, would require a thousand hours." On the basis of the forty-hour week this is practically half of the year, and we have made no mention of other chemical publications, both American and foreign.

To meet this situation there is the publication of the society, *Chemical Abstracts*. In it there is not only a convenient record in duly classified form of all chemical work published in approximately 3,000 journals from all over the world, but there is evidence of thought, care and devotion on the part of its editor and fellow workers that make it a constant inspiration. I doubt if any living man is giving to chemistry more efficient and important service than Evan J. Crane. *Chemical Abstracts* is now in its thirty-fourth year, and when the current volume is compared in size with that of 1906, one wonders what will be the result in 1966 or 76, the centennial year of the society. The stream of publications is becoming so mighty that it threatens to engulf us. We are reminded that Egypt came to its decline when its libraries were filled. But we know also that Egypt had no system of organization for the use of this knowledge such as that which *Chemical Abstracts* furnishes. The curve in Fig. 1 shows the

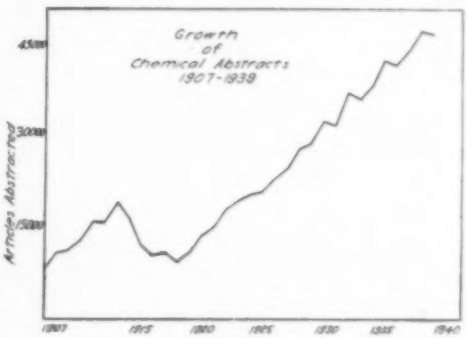


FIG. 1

number of articles abstracted each year, omitting patents. For compactness with exactness and completeness there is much to be said for the place of the biblio-film in the future.

Most interesting in connection with the American Chemical Society have been the men who have served as president. Studying this noteworthy group has been an inspiration. Almost without exception they possess a wonderful capacity for work, and this work lies in widely different fields—from that of practical usefulness to abstruse theory, from the invention of the ink used to print greenback currency and of the flush water-closet (left unpatented that its general

use might bring an improvement in sanitary conditions) to outstanding studies on atomic weights, on the structure of the atom and of the most complex compounds.

It has been a prolific group chemically, the published papers being estimated at five thousand, and the books, usually on chemistry but some on a wide variety of subjects, at several hundred. These presidents include the "chemist of the Southern Confederacy" as well as an assistant surgeon in the Union Army and another Union soldier who was wounded. Nearly a dozen were actively engaged in the World War. In Table 1 are shown their place of birth, residence while president and occupation.

TABLE 1

PRESIDENTS, AMERICAN CHEMICAL SOCIETY, 1876–1941

Place of Birth	
Great Britain	3
Germany	2
Belgium, Canada, Russia—each	1
Massachusetts	11
New York	9
Pennsylvania	4
New Jersey, Ohio—each	3
Connecticut, Kansas, Maryland—each	2
Georgia, Hawaii, Illinois, Iowa, Indiana, Rhode Island, South Carolina, Tennessee, Virginia—each	1
Total	53
Residence	
New York	10
Massachusetts, Pennsylvania—each	8
Illinois	7
District of Columbia	4
Ohio	3
Michigan, North Carolina—each	2
California, Connecticut, Delaware, Iowa, Kentucky, Maryland, Minnesota, New Jersey, Virginia—each	1
Total	53
Occupation	
Teacher	38
Commercial laboratory	4
Industrial research	4
Manufacturing chemist	4
Government chemist	3
Total	53

Not only does America have the largest chemical society, but apparently it had the first—The Chemical Society of Philadelphia—founded by James Woodhouse in 1792. James Kendall claims there was a chemical society in Scotland a few years older, but this seems to have been chiefly a student group at the University of Edinburgh. This American society was active for seventeen yaers, having a decided influence upon the chemical thought of its day and leaving some interesting papers. In an address delivered before this society on April 11, 1798, Thomas P. Smith makes suggestions which are as vital and timely today as they were more than a century ago. He says: "The only true bases upon which the independence of our country can rest are agriculture and manufactures. To the promotion of these nothing tends in a higher degree

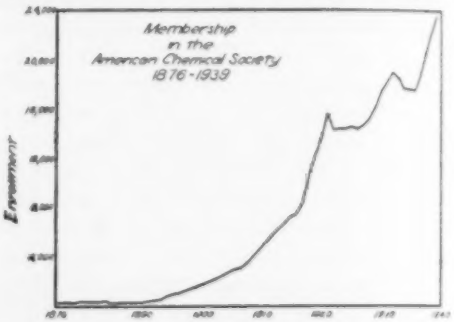


FIG. 2

than chemistry. . . . It is to a general diffusion of a knowledge of this science, next to the virtue of our countrymen, that we are to look for the firm establishment of our independence."

The growth in membership of the American Chemical Society is seen in the curve in Fig. 2. The effects of the World War and of depressions are evident. It is noteworthy that for years the society was not much more than a local New York organization, all the meetings being held in New York City. The membership in 1889 was 204, compared with 230 at the end of the first year. General Meetings, not necessarily in New York, were arranged, the first being held in Newport, R. I., and the

second in Philadelphia, both in 1890. The first local section, that of Rhode Island, was authorized in 1891. During the third general meeting in Washington in August, 1891, a conference of delegates from chemical societies from various sections was held, satisfactory plans were adopted and the growth of the society began again. The incorporation effected in January, 1938, with a national charter approved by act of Congress, August 25, 1937, symbolizes the nation-wide influence of our society.

In a paper entitled "Chemical Societies in the XIX Century," presented at the twenty-fifth anniversary of the society in New York in April, 1901, Henry Carrington Bolton lists 66 such societies and gives their total membership by countries. The total of the seven in the United States ranks fifth, being less than that of Great Britain, Germany, France or Austria. The American Chemical Society in 1900 had twelve sections, only one being in the South and one west of the Mississippi River. Its membership is given as 1,679.

TABLE 2

CHEMICAL SOCIETIES OF THE WORLD (AFTER H. C. BOLTON—1900)

	Societies	Members
Great Britain	10	7,750
Germany	15	7,431
France	11	4,077
Austria	8	2,972
U. S. A.	7	2,575
Japan	2	1,012
Others—7—	13	1,973
Totals	66	27,790

So many phases of our chemical heritage now in evidence might be mentioned that there must of necessity be a selection. Reference will be made only to the development of men and women in chemistry and to the productive chemical capacity of our nation.

The contact of one personality with another has always interested me. This interest was deepened by my good fortune in being a student at the University of Pennsylvania, under Dr. Edgar F. Smith, who in his turn had been greatly inspired as a young man while working under the direction of the elderly Wohler at Göttingen in Germany. If properly catalyzed by student questions, Dr. Smith would talk most entertainingly by the hour of his experiences with Wohler and I think it quite possible we learned more in that way than we might have learned by the regular lesson. Wohler was a student of the great Berzelius in Sweden, who frankly acknowledged that he was the last man who would ever know all of chemistry! For many years Berzelius's word in chemical matters was accepted practically without question. I like to tell my students, then, of their illustrious chemical ancestry in Grandfather Smith, Great-grandfather Wohler and Great-great-grandfather Berzelius.

The influence of this German and of this Swede and of other European teachers has been transmitted by their students and has become as real a part of our American chemical heritage as the Swedish heritage celebrated in Wilmington in 1938. Dr. Smith enjoyed arguing that Wohler had had the greatest influence upon chemistry of any man in America, furnishing as one basis of proof that Wohler had trained many who later became presidents of the American Chemical Society. No doubt a student of Bunsen or of others could furnish contrary arguments equally convincing to him. Certain it is that America owes very much to Europe and most of all to Germany for the early days of its chemical heritage. A chemist can notice on his society pin or button the potash bulb of Liebig, or observe the shape of your Alpha Chi Sigma badge, your Phi Lambda Upsilon key or the insignia of the Chemical Warfare Service, the hexagon of Kekulé. Both Liebig and Kekulé were born in Germany early in the nineteenth century and lived and worked there. In using the words "our society"

I have been reminded of how chemists of the generations before us often spoke of "*our science.*"

It is worthy of note, however, that in accordance with American tradition we have not simply borrowed blindly from Germany, but that we have developed on this soil along every line the ideas germinated there, often enriching and extending them. The chairman of the International Committee of Atomic Weights for many years was Professor Theodore William Richards of Harvard, first American winner of the Nobel Prize in chemistry. To-day one of his pupils at Harvard has succeeded him as chairman, and the German representative on this committee is also a former student of Richards. German chemists are rightfully entitled to much credit for the development of the coal-tar industry and the production from it of dyes, medicines, perfumes, explosives and flavoring materials. During and since the World War American chemists have been making a similar achievement with the typically American products, petroleum and cotton, and in many other fields.

Recently I visited the du Pont alcohol plant in Deepwater under the guidance of an old friend, an alumnus of the University of Arkansas. Not only was I impressed with the appearance and efficiency of this plant, but in looking from the windows of the fermentation building I could see where ethyl fluid was made and was shown the location for the work done on many chemical compounds that later led to industrial triumphs. And I felt that here surely is a place typical of the spirit of American chemistry.

In Tulsa at the meeting of the American Chemical Society in April, 1926, preparatory to its semi-centennial celebration that fall, a dozen outstanding world chemists were elected to honorary membership. Apparently no great difficulty was experienced in selecting the three Americans upon whom this honor was bestowed. Richards of Harvard, Remsen of Hopkins and Smith of Pennsylvania were so clearly preeminent that the choice was relatively easy. Now, only fourteen years later, it would actually be impossible to select with ease the three outstanding chemists of America. The three men chosen in 1926 passed within a few years to their reward, but there have been none since then who have reached a position similar to that held by them. Great as these men were and as much as I admire them, I do not feel that we shall never see their like again. Rather do I think that due in

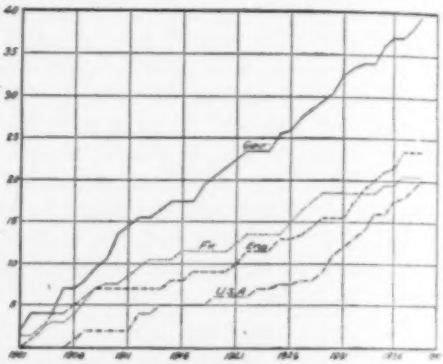


FIG. 3

large measure to their influence and that of their contemporaries, America has developed so many men of ability and power that the entire chemical level has been raised and hence no one is now likely to attain such marked preeminence.

In the winning of Nobel Prizes in science during the 39 years since the awards began, the success of Germany has been noteworthy, as seen in this table and this graph. (Fig. 3).

Of the thirty-four prizes in chemistry only three have come to the United States, the winners being Richards, Langmuir and Urey. England and France have received more and Germany many more. (See Table 3.) However, two of the three have been received

TABLE 3

NOBEL PRIZE WINNERS IN CHEMISTRY, 1901–1939

Germany	15.5
England	5
France	4
U. S. A.	3
Sweden	2.5
Switzerland	2.0
Holland	1
Austria	1
Total	34

within the last eight years and the future holds much of promise. It seems to me that the younger chemists now coming to maturity are not only maintaining, but are actually advancing the standards set by former American chemists. My experience in securing additional members of my department and as a member for three years of the committee of the society responsible for the A. C. Langmuir and the James Kendall awards is the basis of this statement.

The increase in the number of students in chemistry and in the laboratories for their training indicates no shortage of applicants for chemical work. Quantity will not be lacking, but quality is more significant. Some ten years ago 77 out of 78 chemical manufacturers who replied to a questionnaire said that better chemists rather than more chemists were needed. This is at once a challenge both to students and to teachers. It is just as much the duty of any good department of chemistry to keep out the unfit as it is to train the capable. To know just what to teach is difficult. Recently my colleagues have been asking for more time for organic chemistry and for physical chemistry, and they need it. But the capacity of the average student has not greatly increased, and there can be no additions to a four-year curriculum, only substitutions—and what can be omitted? What must be left for graduate study? Cooperation and understanding between industrialists and teachers in the training of chemists are necessary. Here again our society aids. At the Pittsburgh meeting an entire session of the Division of Chemical Education was used for discussing the question, "What Industry Wants of Its Chemists." Outstanding leaders in industrial chemistry, one from Wilmington, made the answer. Even more effective are countless personal contacts between chemists in industry and in teaching. This is one reason I value so highly your invitation.

The increasing number of students in chemical engineering is impressive. The American Institute of Chemical Engineers is not quite half as old as the American Chemical Society. Membership in the institute has been restricted. Its rapid recent growth is shown in Fig. 4. That a recent report shows 2,278

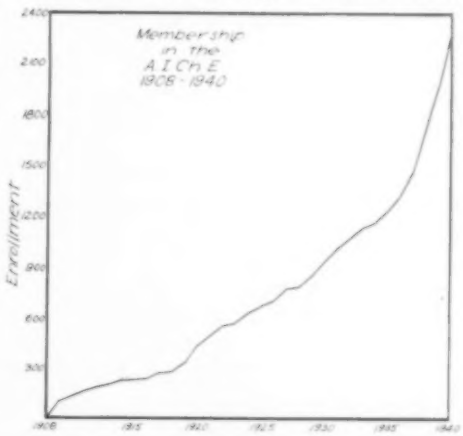


FIG. 4

members of all classes in the parent organization and of 5,000 members in 69 student branches makes one wonder.

Figures given by Professor Alfred H. White before the International Chemical Engineering Congress in London show that the number of undergraduates in engineering in the United States has increased about three times from 1910 to 1935. The number of undergraduates in chemical engineering has increased during this same period more than twelve times. The percentage of students working toward the doctorate among

chemical engineers is far higher than that in any other engineering group.

So much for men and women in chemistry in America; just a word of the material side. In his book on "Men, Money and Molecules," Williams Haynes states that, "In the United States we make more chemicals—measured either in tons or in dollars—than are produced in Germany, England, France, Italy, Japan and Russia, all added together." It is not surprising then to have him remark that, "If the coming era is to be a chemical age in industry, there is every reason for America to be optimistic." We recognize that this is due in part to our natural resources, but it is the result also of an energetic use of these resources. If our position is to be maintained, research on an increasing scale must be continued. This area has set a splendid example in such work. We are hopeful of results of value from the new government laboratories for research on the use of agricultural products. These results will come if the work in them even approaches that done in the Bureau of Standards and certain other state and federal laboratories.

Herbert Hoover has said: "No human person can evaluate the contribution of the science of chemistry to the advancement of civilization. The enormous advance in standards of living, the greater margins of comfort, the lessening of physical exertion required to attain these things, the relief of suffering, the extension of health and life, have all received the most vital contribution by the applied science of chemistry."

Each American chemist has the right to pride and satisfaction in his work, to look forward eagerly to the future and to the difficult task of continued service to the nation and to the world. We see that in American chemistry that has been, is and is to be, there is much of challenge, of inspiration and of hope.

GEOMETRY: THE KEY OF THE SCIENCES

GEOMETRY, to which I have devoted my life, is honored with the title of the Key of the Sciences, . . .

The key! It is of wonderful construction, with its infinity of combination and its unlimited capacity to fit every lock, however varied in form and size, . . .

Begin with the heavens themselves; see how precisely the motions of the firmament have endured through the friction of the ages; observe the exactness of the revolutions of the stars; if these mighty orbs can not resist the law, what can the atom do? Let, then, the resources of art be exhausted in this scrutiny. Let neither time nor labor nor money be spared. A slight defect of motion is just detected; it is slight, very slight, but it is unquestionable. We dare not hide it out of sight. Science must admit this triumph of art and be true even if the stars are false. The names of fixed star and pole-star must not be suffered to impose upon the trusting world, and guide it in a delusive chase after an *ignis fatuus*. Geometry! to the rescue! Geometry is at her post, faithful among the faithless. The pen is at work, the midnight oil consumed, the magic circles drawn by the wise men of the East, and the wizard logarithm summoned from the North. The tables are turned. The defect of motion is transformed into the discovery of a new law. It becomes the proof of the atmosphere to bend the ray from its course as it shoots down, laden with the image of Arcturus and the sweet influences of the Pleiades; it becomes the proof of the moving light, of the unseen planet, and of the invisible star, and hence a new proof of the precision of the measure. Honor to Bradley, to Bessel, to Adams and to Leverrier! The stars are not false. Question them as you may, they give the same evidence and do not contradict each other's testimony. They tell us that ours is not the central sun, and that we are moving in the procession of the stars; they tell us that we move among the others, towards the constellation of Hercules, so that, while we grow in wisdom, we approach the strong man's home. They tell us that we are moving at such a rate that the distance from star to star is but just a good geological day's journey; and hereby they confirm the story which is written upon the crust of our globe and prove that the earth and the skies have been measured out with the same unit of measure.—*Professor Benjamin Peirce, of Harvard University, the foremost American mathematician of his day, from his retiring address as president of the American Association for the Advancement of Science, delivered at Cleveland, Ohio, in July, 1853.*

BOOKS ON SCIENCE FOR LAYMEN

THE INTELLIGENCE OF CRIMINALS[1]

THE author of this volume presents the results of his psychological study of 10,413 prisoners, representing *all* the admissions to three penal institutions in Illinois during the period 1920–1927. The data for the three are separately given, so that the penitentiary and reformatory types of prisoners are not confused. In order that data comparable with the Army draft studies might be secured, the same general procedures and batteries were employed as were used in the Army testing.

Among the chapters we find the following titles, which serve to indicate the scope of the work: Intelligence in Relation to Nativity and Race, Type of Crime and Recidivism; Intelligence in Relation to Age, Height and Weight; Intelligence in Relation to Socio-Economic Characteristics; Type of Crime in Relation to Nativity and Race, Intelligence and Recidivism.

In very brief summary, it may be said that Tulchin finds no startling discrepancy between the test score classification of the inmates and that of the Army draft group; in other words, there seem to be no close association between crime and "intelligence." There is found, however, a relationship between the rating and the general type of offense. "For nearly all nativity and race groups, the highest median Alpha scores are made by the men committed for fraud, and the lowest scores by men committed for sex crimes." Tulchin points out the need of considering the nativity and race distributions of institutions in making comparisons: considerable variations of rating are found in relation to these factors.

The volume represents one of the many valuable contributions to the literature of forensic psychiatry inspired and initiated by the late Dr. Herman M. Adler, to whose memory the book is dedicated. It is comprehensive, thorough, sound, clear and informative. It should, and undoubtedly will, be read by every one interested in psychometrics, criminology and mental deficiency, as one of the most significant studies of its kind. The fact that the book is planographed detracts very little from its readibility.

WINFRED OVERHOLSER, M.D.
SAINT ELIZABETHS HOSPITAL,
WASHINGTON, D. C.

[1] *Intelligence and Crime.* By Simon H. Tulchin. xiii + 166 pp. $2.00. 1939. University of Chicago.

RECENT BOOKS ON BIRDS

"CANADIAN Water Birds. Game Birds. Birds of Prey. A Pocket Field Guide"[1] is a welcome addition to the ever-increasing list of fully illustrated, popular, but scientifically accurate and authoritative manuals for bird identification. Unlike most other books in its general class, the present one is intended primarily for the sportsman and its contents are limited to water birds, game birds and birds of prey, leaving out altogether the small song birds, the woodpeckers, the cuckoos and other related groups. (These birds are covered in a companion volume.) The keys for identification are made as simply as possible, and the lavish use of illustrations (nearly 100 plates in color and over 150 text drawings in black and white depicting nearly 200 different species) is obviously directed at helping the novice to make his identifications with the least waste of time and with the greatest probability of accuracy of result. The book is highly recommended by the reviewer.

"WILD Bird Neighbors"[2] is of a very different type, being a series of first-hand

[1] P. A. Taverner. 291 pp. $2.50. 1940. David McKay Company.

[2] Alvin M. Peterson. 283 pp. $2.00. 1940. The Bruce Publishing Company.

field studies of about thirty-five common species of birds, to each of which is devoted a small chapter. While the bulk of the material is not such as to constitute additions to existing knowledge, the fact that the notes and photographs (many of which are excellent) are all original makes the book worth reading. It is written in an interesting, easy style, which should make it a good book for beginners and people to whom the study of birds in the field is a mild and pleasant avocation.

The last of the books herein reviewed deals with a single species. "The Autobiography of an Egret"[3] is a book of superb photographs (39 illustrations) of one of our most attractive and beautiful birds. The fact that the author did a good deal to save this species from local extermination at a time when it was seriously depleted by the plume hunters for the millinery trade explains a rather too obvious sentimentality in parts of the text. The book is written in the first person as though an egret were telling the story, a type of writing that may have its advocates, but which leaves the reviewer inclined to be unsympathetic and hypercritical. There is much valuable material in the book, if one knows how to extract it from the narrative in which it lies imbedded.

HERBERT FRIEDMANN

LET US REASON TOGETHER[1]

IF John Dewey ever wrote anything that was not worthy of careful reading by thinking persons, it has escaped my attention. This latest book of his not only exhibits his penetrating insight and precision of statement, but it is almost tragically timely. It discusses the question of individual freedom at a time when it has disappeared from a large part of the world and is giving rise to hysteria in the remainder.

Dewey opens with a discussion of "The Problem of Freedom" in which he inquires concerning the reasons men have had for desiring individual liberty. "Is love of liberty ever anything more than a desire to be liberated from some special restriction? And when it is got rid of does the desire for liberty die down until something else feels intolerable?" There is no simple, categorical answer to such questions, and Dewey does not give one. As he shows, human motives are enormously involved, and many of the tragic mistakes of mankind have been due to over-simplification of things that are fundamentally complex. His third chapter on "The American Background" will be especially illuminating to American readers because it raises questions concerning the origin and the meaning of the lofty sentiments found in the Declaration of Independence and the Constitution of the United States. This discussion will be illuminating because the intelligent American reader will have a background of historical information and attitudes that will make its statements easily comprehensible. But few will have the broad knowledge of history, psychology and philosophy necessary to grasp readily the full content of his pages on "Totalitarian Economics and Democracy" and "Democracy and Human Nature." This fact is not a good reason for not reading this book with care. On the contrary, the reader should be grateful that so much knowledge and wisdom are available in such a small compass.

In the final chapter on "Democracy and America" Dewey does not make "the eagle scream" or point to any easy and certain road to Utopia. "We have no right to appeal to time to justify complacency about the ultimate result. We have every right to point to the long non-

[3] Edward A. McIlhenney. 58 pp. $2.00. 1939. Hastings House.

[1] *Freedom and Culture.* By John Dewey. 176 pp. $2.00. 1939. G. P. Putnam's Sons.

democratic and anti-democratic course of human history and to the recentness of democracy in order to enforce the immensity of the task confronting us. . . . We have every right to appeal to the long and slow process of time to protect ourselves from the pessimism that comes from taking a short-span temporal view of events—under one condition. We must know that the dependence of ends upon means is such that the only ultimate result is the result that is attained today, tomorrow, the next day, and day after day, in the succession of years and generations. Only thus can we be sure that we face our problems in detail one by one as they arise, with all the resources provided by collective intelligence operating in cooperative action. At the end as at the beginning the democratic method is as fundamentally simple and as immensely difficult as is the energetic, unflagging, unceasing creation of an ever-present new road upon which we can walk together."

F. R. MOULTON

BIOLOGY MADE SIMPLE: TOO SIMPLE[1]

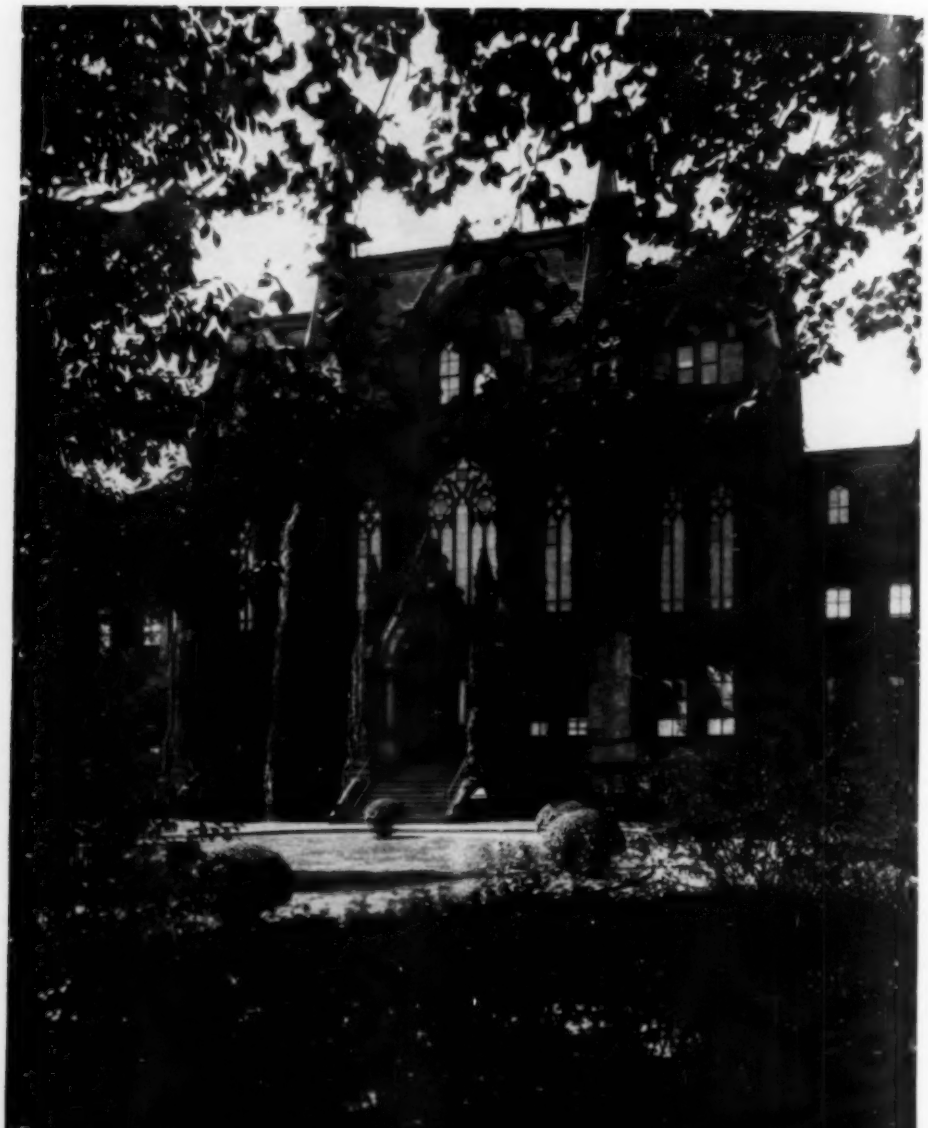
THE human body is wondrously constructed and its multitude of intricate and nicely balanced activities are fascinating subjects to all. The average "man on the street" is woefully ignorant of his own person: what he is, how he is made and how he "works." As a result, more of us abuse our machines than use them. To describe and discuss the significance of human biology in such manner that the fundamentals are clarified to the uneducated lay reader is a splendid objective. This little book, sponsored by the American Association for Adult Education, ambitiously attempts, but does not succeed, to explain the evolution of mankind, human anatomy, the physiology of muscles, digestion, metabolism, circulation, immunity, respiration, reflex action, thought and reproduction, all in 125 small pages.

The accomplishment falls so far short of the objective that one could hardly recognize the latter but for an explanatory note. Though there are few, if any, absolute mis-statements of fact in the book, much of the material is so vague and idealistic that a grossly false sense of inane simplicity prevails. As reading matter for the fifth grade it could do much good. The whole style is that of a story-book for children. The reiteration of the personal pronoun becomes a burden and a bore. If the Committee for Adult Education deems such phraseology as "On St. Valentine's Day true lovers send each other a picture of a pump. That is what your heart is . . . " appropriate for adult education, it is a sad commentary upon their opinion of adult intelligence in America. Much more harm can be done by "talking down" with baby talk to those innumerable adults hungry for factual knowledge than by an occasional technical expression which may require amplification. These people want to look up, to be stimulated and bitterly resent such pap as this. Lack of education does not imply stupidity nor even lack of curiosity. If this oversimplification is intended to intrigue the curiosity of the dull ignoramus it will likewise fail, for he is sincerely convinced that he already "knows it all."

Similarly, the illustrations are detrimental to clarity. Attempting to be simultaneously diagrammatic and sensationally dramatic they merely confuse and mislead. This book can not be recommended except for small grammar-school children, and for them there are far better biology texts. It is too simple.

EDWARD J. STIEGLITZ

[1] *Picture of Health.* By James Clarke. Illustrated. 125 pp. $0.60. 1940. Macmillan Company.



COLLEGE HALL OF THE UNIVERSITY OF PENNSYLVANIA

THE PROGRESS OF SCIENCE

THE BICENTENNIAL CELEBRATION OF THE UNIVERSITY OF PENNSYLVANIA

A BICENTENNIAL Conference will be held by the University of Pennsylvania, beginning September 16 and ending September 20, as part of the program marking the observance of the two hundredth anniversary of the university's origin. The program will consist of lectures and papers by a group of about two hundred distinguished European and American scholars and leaders in the various fields of science and thought. The offerings will represent the broad interests and significant contributions to learning. In the field of the humanities the symposia are planned to bring out the continuity of culture. In other fields they will trace the trends of modern thought and the advances of science. The symposia and meetings constituting the program of the Bicentennial Conference are divided into six general fields—the medical sciences, the natural sciences, the social sciences, the humanities, the fine arts and religion.

The fullest section of the program, with fifty-eight papers, is that on the medical sciences. A heavy advance registration reflects wide-spread interest in sulfanilamide and its derivatives, one of the most effective medicines discovered during this century. Dr. Eli K. Marshall, Jr., of the Johns Hopkins University, and Dr. John S. Lockwood, of the University of Pennsylvania, will review the efficacy of these drugs and the mechanism of their action. The search for germ-killing chemicals, involving the study of bacterial enzymes will be described by Dr. René Jules Dubos, of the Rockefeller Institute for Medical Research.

The symposium on nutrition will be addressed by Dr. Elmer V. McCollum, of the Johns Hopkins University, co-discoverer of vitamin A and a leading investigator also in vitamin D and mineral metabolism; Dr. Conrad A. Elvehjem, of the University of Wisconsin, outstanding worker in the continually broadening field of the vitamin B complex; and Dr. Cyril N. H. Long, of Yale University, known for his work in endocrine gland research.

Dr. Lawrence J. Henderson, of Harvard University, noted for his studies on the physico-chemical relationships in the blood, will deliver one of the principal addresses. He will concern himself with the social as well as the medical aspects of man under the broad topic, "The Study of Man." Dr. William Mansfield Clark, of the Johns Hopkins University, will be another of the principal speakers in this section, and Dr. Evarts A. Graham, professor of surgery at Washington University, will speak on "Two Centuries of Surgery."

The medical symposia will cover a wide variety of subjects besides those already mentioned. They include sessions on the female sex hormones, diseases peculiar to old age, virus diseases, problems of high blood pressures, new leads on the search for the cause of cancer, and the relation of animal diseases to human welfare.

The round table on the history of science, ranging from "The Mesopotamian Background for the Beginnings of Science" to "The Rise of Modern Scientific Medicine," is attracting much interest in the field of the natural sciences, which is the second largest of the six main divisions of the program. To mention a few of the outstanding names on the program, there are: Dr. Otto Eduart Neugebauer, formerly of Germany, now of Brown University, and one of the leading authorities on the history of mathematics and astronomy; Dr. Henry E. Sigerist, director of the Institute of the History of Medicine of the Johns

THE UNIVERSITY MUSEUM

Hopkins University; and Dr. George Sarton, editor of *Isis* and *Osiris*, and lecturer on the history of science at Harvard University. Dr. Sárton will act as chairman of the round table.

Secretary Henry A. Wallace, of the United States Department of Agriculture and the Democratic nominee for vice-president, has recently accepted an invitation to address the symposium on the conservation of renewable natural resources, a matter of increasingly serious concern. Another participant will be Dr. Paul Bigelow Sears, of Oberlin College. Determination of the American climate and weather of several thousand years ago by means of well-preserved "fossil" grain pollens, and the accurate dating of droughts, wet spells and ancient human habitations by means of tree rings are among the topics to be discussed by Dr. Sears, and by Dr. Andrew E. Douglass, of the University of Arizona.

A particularly large advance registration has been made for the psychology symposium which deals with the contribution of this study to education and business.

The meeting on nuclear physics, to be addressed by the Nobel Prize winner, Dr. Enrico Fermi, formerly of Rome and now of Columbia University, also is attracting considerable advance interest as are the sessions on genetics, evolution and heredity, and several others. Dr. Frank B. Jewett, president of the Bell Telephone Laboratories and of the National Academy of Sciences, will make one of the principal addresses.

Herbert Clark Hoover, who will speak Wednesday evening, heads an impressive list of speakers in the social science field. Other notables include Hu Shih, Chinese Ambassador to the United States, Dr. Wesley Clair Mitchell, professor of economics at Columbia University and noted for his work on index numbers and business cycles. The war refugee problem will be considered in a

group of papers on "Forced Mass Migrations."

Industrial relations will be discussed by six members of a panel, including William M. Leiserson, of the National Labor Relations Board; James M. Landis, dean of the Harvard Law School, and Joseph Willits, director for the Social Sciences for the Rockefeller Foundation. Dr. Willits will act as chairman.

The social implications of modern architecture will be among the topics taken up in the fine arts section by such speakers as Joseph Hudnut, dean of the faculty of the Harvard University Architectural School, and Frank Lloyd Wright, pioneer in the development of modern architecture.

Two distinguished Frenchmen will address the conference in the fields of religion and humanities: Dr. Maritain, author and philosopher of the Catholic Institute of Paris and the Institute of Medieval Studies of Toronto, will speak on "Trends in Religious Thought"; Professor Gilson, who is professor of medieval philosophy at the College of France, and director of the Institute of Medieval Studies at the University of Toronto, will give a lecture on "The Middle Ages and the Unity of Western Civilization."

In addition to the Bicentennial Conference, the program for the University of Pennsylvania's Bicentennial Week Celebration from September 16 to 21 will include cultural and scientific exhibits, laboratory and clinical demonstrations, convocations for the conferring of honorary degrees, meetings for alumni and alumnae, and a number of other events.

On the afternoon of September 20, the Philadelphia Convention Hall, near the campus, will be the scene of impressive exercises which will include a Convocation of the University Council for the conferring of honorary degrees upon President Franklin D. Roosevelt and Sir

THE ZOOLOGY BUILDING

Lyman Poore Duff, Chief Justice of the Supreme Court of Canada. Both President Roosevelt and Sir Lyman will deliver addresses during the convocation, at which President Thomas S. Gates of the university will preside; there also will be an address by Justice Owen J. Roberts, of the Supreme Court of the United States.

At the closing convocation on September 21, approximately five hundred delegates representing universities, colleges, and learned societies at the Bicentennial Celebration will be presented formally, and the university will confer honorary degrees upon a score of men distinguished in various fields. In addition, the program will include addresses by Governor Arthur H. James, of Pennsylvania; President Gates, and Dr. George Wm. McClelland, provost of the University of Pennsylvania. H. L. H.

NATIONAL DEFENSE RESEARCH COMMITTEE

THE National Defense Research Committee was set up under an order of the Council of National Defense dated June 27, 1940. The order recites that the committee "shall correlate and support scientific research on the mechanisms and devices of warfare, except those relating to problems of flight included in the field of activities of the National Advisory Committee for Aeronautics. It shall aid and supplement the experimental and research activities of the War and Navy Departments; and may conduct research for the creation and improvement of instrumentalities, methods and materials of warfare." In

FIRST MEETING OF THE NATIONAL DEFENSE RESEARCH COMMITTEE

Seated, left to right: BRIGADIER GENERAL G. V. STRONG, DR. JAMES B. CONANT, DR. VANNEVAR BUSH, *chairman*, DR. RICHARD C. TOLMAN, *vice-chairman*, DR. FRANK B. JEWETT AND (*standing*) DR. KARL T. COMPTON, DR. IRVIN STEWART, *secretary*, AND REAR ADMIRAL HAROLD G. BOWEN.

carrying out its functions the committee is empowered to enter into contract with organizations and individuals. The members of the committee are:

Vannevar Bush, *chairman*
President, Carnegie Institution of Washington
Richard C. Tolman, *vice-chairman*
Dean of the Graduate School,
California Institute of Technology
Rear Admiral H. G. Bowen
Designated by the Secretary of the Navy
Conway P. Coe
Commissioner of Patents
Karl T. Compton
President, Massachusetts Institute of Technology
James B. Conant
President, Harvard University
Frank B. Jewett
President, National Academy of Sciences
Brigadier General G. V. Strong
Designated by the Secretary of War

The committee will act in close cooperation with the War and Navy Departments. So far as possible the committee expects to utilize existing facilities, and it will act directly only where there is reason for such direct action. The committee is accumulating information as to special research facilities of academic and industrial organizations which might be brought to bear upon particular defense research problems. The response which has already been received from scientists both in academic institutions and in industry shows clearly that the committee will have the cordial cooperation of this entire scientific group in its efforts.

The relations between the committee on the one hand and the National Academy of Sciences and the National Research Council on the other, will be quite close. Work already under way by the Academy and Council will continue; and the committee will cooperate with the academy and the council as they proceed on additional problems which they undertake in their capacity as the organizations primarily charged with the duty of advising agencies of government on their scientific problems.

There will also be a close working relationship between the committee and the newly created Inventors' Council. The council, in close contact with the Army and Navy, will make a preliminary appraisal of the usefulness of new ideas and inventions, and there will be referred to the committee those upon which further scientific research is needed to complete development and insure utility.

Because of the nature of the problems with which it will deal, the committee will not reveal the particular problems upon which it may be engaged at any time. Its primary purpose will be to bring to bear upon the problem of the creation and improvement of the devices and mechanisms of warfare the efforts of competent civilian scientists and engineers to supplement the work already being carried on directly by the armed services.

VANNEVAR BUSH,
Chairman

AWARD OF THE NOBEL PRIZES IN CHEMISTRY

THE will of Alfred Bernhard Nobel, who died in 1896, provided that the bulk of his vast munitions and oil fortune should be placed in trust for the establishment of five annual prizes to be awarded for contributions to physics, physiology and medicine, chemistry, literature and peace. The will stated, "I declare it to be my express desire that, in the awarding of prizes, no consideration whatever be paid to the nationality of the candidates."

The Royal Swedish Academy of Sciences in Stockholm several months ago announced the Nobel Laureates in Chemistry for 1938 and 1939. Chosen for the delayed 1938 award was Professor Richard Kühn of Heidelberg and jointly for the 1939 award were Professor Adolf Friedrich Johannes Butenandt of Berlin

PROFESSOR RICHARD KÜHN

and Professor Leopold Ružička of Zurich. Professors Kühn and Butenandt are honored no less because the German government will no longer permit its subjects to accept Nobel Prizes. It took this stand in 1935 because Carl von Ossietzky—then in a concentration camp—was designated as the recipient of the Nobel Peace Prize.

Professor Richard Kühn was born in Vienna on December 3, 1900. He achieved his early training under Willstätter and became a *privat-dozent* at the University of Munich in 1925. The next year he went to Zurich as professor and at the age of 30 became head of the department of chemistry of the Kaiser Wilhelm Institute for Medical Research when it opened in Heidelberg in 1930. In 1937 he was made director of the institute.

Professor Kühn's investigations embrace important contributions to many problems in organic and physiological chemistry. His early work was in the field of pure organic chemistry, where he was able to synthesize and study the behavior of long chains of unsaturated hydrocarbons. This led naturally to the study of the carotenes, and in this

PROFESSOR LEOPOLD RUŽIČKA

field Kühn made important contributions to the knowledge of the structure of vitamin A.

Simultaneously with Karrer, Kühn described the constitution of riboflavin, vitamin B_2, and further showed its relationship to the yellow enzyme of Warburg, which is involved in the oxidation of sugar in the body cells. His most recent publications are concerned with the chemistry and biological properties of certain substances found in lower organisms.

Although carried out in separate laboratories, the investigations of Professors Ružička and Butenandt in the field of the male sex hormones are peculiarly complementary, and the joint award of the 1939 Nobel Prize in chemistry was appropriate.

Professor Leopold Ružička, who was born on September 13, 1887, at Vukovar, Yugoslavia, received his degree in engineering and became *privat-dozent* at Zurich in 1918, where he has remained with the exception of three years spent as professor at the University of Utrecht. He is now professor of chemistry at the University of Zurich.

Ružička first became widely known for his synthesis of musk, greatly in demand as an ingredient of perfumes. This synthesis, besides showing the existence of a new class of chemical compounds, saved from possible extinction the now rare musk oxen of Tibet.

Dr. Adolf Butenandt was born on March 24, 1903, in Wesermunde, Germany. He studied at the University of Marburg and achieved his doctorate at the University of Göttingen, where he remained as *privat-dozent* under Professor A. Windaus until 1933. He was then for three years professor at the

PROFESSOR ADOLF FRIEDRICH JOHANNES BUTENANDT

University of Danzig and in 1937 he became director of the Kaiser Wilhelm Institute of Biochemistry in Berlin. The training under Windaus, himself a Nobel Prize winner for his studies on the vitamin D and bile acid steroids, provided a thorough basis for Butenandt's comprehensive investigations on the sex hormone steroids.

Following the discovery by Zondek and Aschheim a little over a decade ago that the urine of pregnant women was rich in female sex hormones, Butenandt made important contributions to the knowledge of the structure of these compounds. In addition he worked out the formula of an inactive steroid, pregnanediol, found in pregnancy urine by Marrian. Several years later this substance was shown to be an excretion product of progesterone, a pregnancy-maintaining principle of the ovary, whose formula had similarly been determined by Butenandt. Of this demonstration, Willard M. Allen, of the University of Rochester, wrote in 1939, "The fact that the structure of pregnanediol was already known was of course of the greatest importance, and the beautiful work of Butenandt establishing its structure years before it appeared to have any relation to the sex hormones is a classical example of the value of science for its own sake."

Although the investigations of Ružička contributed substantially to the knowledge of the structure of the female sex hormones, the landmarks of his work are more pronounced in the field of the male sex hormones, which developed somewhat later.

When attention turned to the steroids found in male urine, Butenandt succeeded in isolating in 1934 the first male hormone in crystalline form, androsterone. Ružička described in 1934 and 1935 the experiments definitely establishing its chemical structure. He was able to start with a common steroid found throughout the body, cholesterol, and by

appropriate chemical treatment transform it into the potent male hormone, androsterone.

Another male hormone, considerably more potent than androsterone, was found by Gallagher and Koch in extracts of bull testis. By the time Laquer had isolated this hormone in crystalline form, both Ružička and Butenandt had succeeded in preparing it synthetically from cholesterol, and the structure of testosterone, the most potent male hormone known, was proven.

Butenandt demonstrated the structure of another hormone in male urine, dehydroandrosterone, and showed its relationship to androsterone. Later he was able to start with a vegetable steroid, stigmasterol, and from it synthetically produce both male and female sex hormones.

Due to the complexity of the molecules of the sex hormones, many closely related derivatives of these substances are theoretically possible. It has been amply demonstrated for many chemical compounds that a slight change in the molecule will induce tremendous changes in its activity. In the cause of pure science as well as in the pursuit of more active hormones, Butenandt and Ružička explored in a systematic manner the field of compounds related to the male sex hormones. Their achievements in this pursuit comprise a long list of substances derived from male hormones which they have synthesized and biologically assayed, finding some less active than testosterone in male properties, some without activity and some with female properties.

The isolation of androsterone by Butenandt and its synthesis by Ružička made possible the first international standard for male hormones, established in 1935 on the basis of androsterone.

C. P. Kraatz
Chicago Medical School

AN AURORA IN A TEST-TUBE

Perhaps no effect produced in the planetarium is more popular than the aurora. For several years we have had one in the north and another in the south, and it was a revelation to the audiences to know that there were southern as well as northern lights. While these projection devices produce light patterns on the sky that resemble some types of auroral displays, they do not show the cause of this ghostly light.

To supply this need we have built a glow tube demonstrator that is shown and simply explained in the preliminary talk that precedes each planetarium demonstration. In order to make the connection with northern lights clear we built the tube into a sky background and concealed the apparatus.

The glass tube is about 4 feet long and 3 inches in diameter, made of Pyrex glass. In each end is an electrode made of aluminum. A 15,000 volt transformer is connected across the terminals. The one we use is the ordinary neon sign type. The leads are brought up through fiber tubes for protection and to conceal them from view.

At the center of the tube, and on the side turned away from the audience, is a stop-cock for controlling the pressure on the tube. A Hivac pump is connected at one end of the tube.

In operation, the stop-cock is closed, the pump started and the transformer circuit closed. While the air pressure inside the tube drops, brush discharges appear on the electrodes. Within about two minutes after starting a flash or two across illuminates the tube and finally a salmon red glow. At first the glow is very unsteady, breaking down into a series of short bright and dark spots, locally known as "frankfurters." This

THE "AURORA-PRODUCING" GEISSLER TUBE

is not a bad name as that is exactly what they look like. This unstable condition finally gives way to a steady state of glow.

After further reduction of pressure bright spots appear about two inches apart along the tube. By means of an alnico magnet these rings or disks are moved along in various ways. At the end of about six minutes, the stop-cock is opened and the tube brought back to atmospheric pressure.

No attempt is made to go into the physics of either this Geissler tube or the

THE "NORTHERN LIGHTS" PROJECTED ON PLANETARIUM SKY

BRIGHT-COLORED STREAMERS ARE SEEN AGAINST THE NORTHERN SKY, WITH THE LUMINOUS CLOUDS ABOVE THE HORIZON.

aurora. The simple explanation includes the source of this auroral glow in the sun-spots and the similarity to the electrical energy from the transformer. The exhausting of the tube is compared to going high up into the stratosphere where the aurora appears. The magnetic influence of the earth attracting the glow and causing it to move so mysteriously is illustrated with the magnet's effect on the tube's light.

The experiment has proved most interesting and is one of a series that we perform each month to illustrate some part of the month's topic. A somewhat similar use was made of the glow tube at the Fels Planetarium several months ago. In Dayton C. Miller's book, "Sparks, Lightning, Cosmic Rays," based on his 1937 Christmas Week lectures at the Franklin Institute, an illustration of this hook-up is shown and references given for even more complete study than he gives this type of apparatus.

The rich coloring, violet and salmon red, the notion of "an aurora in a test-tube," proves to be an exciting experience to the audience.

WILLIAM H. BARTON, JR.

TAFFY HAS MERITS

OLD-FASHIONED molasses is placed at the head of the list of iron-containing foods that are useful in the treatment of nutritional anemia, by the studies recently completed at the Massachusetts Institute of Technology.

They show that the old childhood delicacy of molasses on bread may have been a good medicine for growing children, among whom, as they found, nutritional anemia is prevalent. With experiments in the test-tube and on rats, Dr. Robert S. Harris, Dr. John W. M. Sunker and L. Malcolm Mosher have found that molasses is a rich, easily available and relatively inexpensive source of food iron. In effectiveness, it compares favorably with chemicals customarily injected into the blood of anemic people.

That the poorer and less refined grades of molasses are richer in iron that can be used by the body to build hemoglobin (the red coloring matter in the blood corpuscles) than the higher grades is also revealed by the experiments. Since molasses is a by-product of the manufacture of sugar from sugar cane, the removal of greater amounts of sugar from the cane leaves more concentrated residues of the other constituents, among them iron.

A table has been prepared by the institute's biochemists to show the position of molasses with respect to usable iron in comparison with other common foods that contain iron. Molasses stands at the top of the list, with about 6.1 parts of usable iron per 100,000 parts by weight of molasses. Beef liver stands second, with 5.6 parts per 100,000, and oatmeal third, with 4.6. Apricots, eggs and raisins, foods listed by some doctors as especially valuable in curing anemia, were found to contain only about two thirds, a half, and a third, respectively, as much usable iron as does molasses. Spinach is far down on the list, with only 0.5 part per 100,000.

The Institute scientists began by observing that recent medical studies on anemia have shown that the deficiency disorder is more prevalent than had been suspected. More than 40 per cent. of infants are anemic, and the blood of as high as 70 per cent. of adult women was found to be deficient in iron. Few individuals were found with absolutely normal blood.

They also observed that molasses was known to be rich in iron, but that little was known about how much of that iron the body can use. They proceeded to

investigate by means of two different methods—one biological and the other chemical.

In the biological tests, a group of rats was fed on diet low in iron for about a month to produce a nutritional anemia. Then measured amounts of three grades of molasses were added to their diets. Subsequent tests of the blood from the rats showed that the molasses caused definite increases in the amounts of hemoglobin, the less refined the molasses the better the results.

In the chemical tests, the amounts of "ionizable" or soluble iron in molasses were measured directly by chemical methods. Of course, the value of a food as a source of iron is not measured by its total iron content, but by the amounts of its "usable" iron. J. J. R.

A MILLION VACCINATIONS FOR YELLOW FEVER

JUST as the workers of the Rockefeller Foundation were concluding, a few years ago, that the organism (virus) which produces yellow fever had become as extinct as the Dodo, this serious disease reappeared in various areas in South America. It struck in many places from 500 miles north of the equator to 2,000 miles south of it, from the eastern slopes of the Andes to the mouth of the Amazon, from sea level to an altitude of 5,000 feet. Approximately 40,000,000 persons were exposed to the attacks of an invisible and deadly enemy against which they had no means of protection.

All earlier yellow fever was transmitted to human beings by the *Aëdes aegypti* mosquito, the life cycle of the causative virus being mosquito-man-mosquito. Consequently the disease could be stamped out by destroying all infected human beings or all infected mosquitoes—the latter were chosen for the sacrifice. The new yellow fever virus has not been found to be transmitted to man by any mosquito; in some unknown way it steals out of the jungle and slays its victims. In spite of its different method of transmission, it is indistinguishable from the earlier form both in its effects upon human beings and in their acquiring immunity to it. The two strains of virus producing the disease differ sensibly only in the host for a part of their life cycle.

Although mosquitoes are not hosts to the new strain of yellow fever virus, it is not necessary to destroy its only other known hosts, human beings, in order to prevent its spread. In 1937 a vaccine, Virus 17 D, was developed in the laboratories of the International Health Division of the Rockefeller Foundation, after a period of experimentation with monkeys. By the end of 1937, 40,000 persons had been vaccinated with Virus 17 D; at the end of 1938 the number vaccinated had reached 1,059,252. During the year only eight cases of yellow fever developed among persons who had been vaccinated, and in six of these cases the onset of the disease was within four days of vaccination. The immunity is believed to be effective for at least a year, perhaps longer.

In his "Review" of the work of the Rockefeller Foundation for 1938, Dr. Raymond B. Fosdick suggests that conquering disease may be a moral equivalent of war. Certainly those who spend a large part of their lives in Brazilian jungles have high adventure. They learn what it is to remain steadfast during long periods of uncertainty; they taste of defeats as well as of victories. They burn with that restless energy that is leading man to control all the world except himself. Often they, too, stand at a Thermopylae or a Karelian Isthmus.

F. R. M.